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Eric, Xmas, '12.
from Uncle Sidney.

RACING THE LONDON AND MANCHESTER EXPRESS

Paulhan on his Historic Flight from London to Manchester in April, 1910.

THE ROMANCE OF AERONAUTICS

THE ROMANCE OF AERONAUTICS

AN INTERESTING ACCOUNT OF
THE GROWTH & ACHIEVEMENTS OF ALL
KINDS OF AERIAL CRAFT

BY

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"CANTOR LECTURES ON AERONAUTICS" (ROYAL SOCIETY OF ARTS), 1909
&c. &c. &c.

WITH 52 ILLUSTRATIONS & DIAGRAMS

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PREFACE

IN collecting the material for this book, which seeks to convey some impression of the romance and adventure that have ever characterised research and experiment in aerial navigation, I have been assisted by many people. And I desire to acknowledge the kindness of Messrs. Wilbur and Orville Wright, who assisted me in chapters xvii, xviii, and xix by giving me permission to use certain material that was published first in America, and who also guided me in the selection of other matter relating to their work. Also, I am under an obligation to the various publishers for permission to make extracts from *My Airships*, by Santos-Dumont (London: Mr. Grant Richards; New York: The Century Company); *The Aviator's Companion*, by Messrs. Farman (Messrs. Mills & Boon); and *Andrée and his Balloon*, by Lachambre and Machuron (Messrs. Constable). The diagrams on pages 24, 46, and 48 were lent by the Aeronautical Society, and the diagrams on pages 226 and 227 by Messrs. Longmans, Green & Co.

CHARLES C. TURNER.

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CHAPTER I

THE FASCINATION OF THE AIR

"Has the evolution of the human species taken a wrong turn? Why do we belong to the earth rather than to the air or the sea? The desire to possess wings, the dreams in which, without astonishment, we believe ourselves to be flying, what do they mean?"—IBSEN.

MAN'S aspiration towards flying no sooner inspired experiment and bold attempt than the world was thrilled with examples of amazing courage and with the adventures and martyrdom of the pioneers. The reality surpassed the fancies of the poets. During ages when it was considered wildly impracticable the poets loved to imagine human flight. In their writings it was performed by supernatural beings. Only the crazy believed that men would ever fly. Yet how persistently the glorious idea haunted the minds of men is shown in the mythology of almost every nation. We are not here concerned with these stories except to refer, in passing, to the great beauty of some of them, a beauty that was due largely to the very nature of the subject. Let the reader turn to Horace, to Euripides, to Ovid, to Homer, to Pindar, to Ariosto, to Claudian, and to Tasso, and in each he will find some wonderful story of the aerial journey of an angel or some mythical being. Romantic and beautiful as these are, the realisation of the dream of aerial conquest soon provided histories no less romantic and inspiring.

Before turning to the history of actual attempts of men to fly, let us, for the sake of comparison, refer to one of the most striking myths which is, however, curiously little known, the ancient Teutonic legend of Wieland the Smith. Lieutenant-Colonel Moedebeck gives the story in his *Pocket-Book of Aeronautics*:—

"On the command of King Nidung of North Jutland the tendons of both feet of Wieland, an inventive genius, were cut through. In order to travel about in spite of this difficulty, Wieland built himself a flying cloak for which his brother Egil provided him with the feathers. The latter had also to make the first trial with the completed apparatus. Wieland instructed his brother to fly against the wind, and gave him purposely the false advice to descend with the wind, since he feared that his brother might fly away with the cloak. In descending, therefore, Egil had a terrible fall. On the pretence of improving the apparatus, Wieland put it on himself, with the aid of his brother, and at once flew away to his fatherland."

One story goes that at the beginning of the Christian era Simon the Magician, who founded an anti-Christian sect, in order to prove that there was nothing supernatural in the Ascension, manufactured a machine resembling a fiery chariot and made several flights at Rome. Needless to say, no particulars of the machine or of its flights have come down through any trustworthy channel.

It cannot be claimed that the authentic adventures of the first two or three men who risked their lives in experiments compare with these legends for dramatic effect and picturesqueness. Before concerning ourselves with history, however, it were well briefly to mention a few half-believed tales which almost seem to show that long before the brothers Montgolfier lived, the secret of rising into the air by means of the ascensional power of hot air or of gas was known, and also that long before the beginning of the nineteenth century there were definite attempts at aviation, or mechanical flight.

It is said that about the end of the eighth century persons who lived near Mont Pilatus in Switzerland, knowing by what means pretended sorcerers travelled through the air, resolved to try the experiment, and that they compelled some poor people to ascend in an aerostat. This descended in the town of Lyons, and the aeronauts were at once arrested and taken to prison, the mob clamouring for their death. The judges condemned them to be burned, but Bishop Agobard suspended the execution, and sent for them in order that he might question them. The prisoners made the following statement: "Some persons of importance obliged us to come hither, promising that we should see wonderful things. It is true that we descended through the air." Agobard, though he could not believe this fact, perceived that they had no evil intentions, and allowed them to escape. Soon afterwards he wrote a book on superstitions of the day, in which he demonstrated the impossibility of rising in the air.

Numerous old stories are quoted in that aeronautical classic *Astra Castra*, by Hatton Turnor. From Remigius (*Daemonolatria*, chap. xxv.) this author quotes: "Barbelina Rayal states that tubs turned upside down were propelled through the air by sorcerers."

From Kircher's *Ars Magna Lucis et Umbrae* we have the following: "I know that many of our fathers have been rescued from the most imminent dangers among the barbarians of India by such inventions. These were cast into prison, and whilst they continued ignorant of any means of effecting their liberation some one, more cunning than the rest, invented an extraordinary machine, and then threatened the barbarians, unless they liberated his companions, that they would behold in a short time some extraordinary portents, and experience the visible anger of the gods. The barbarians laughed at the threat. He then had constructed a dragon of the most volatile paper, and in this he enclosed a mixture of sulphur, pitch, and wax, and so artistically prepared all his materials that when

ignited it would illumine the machine and exhibit the following legend in their vernacular idiom: 'The Anger of God.' The body being formed and the ingredients prepared, he then affixed a long tail, and committed the machine to the heavens; and, favoured by the wind, it soared aloft towards the clouds. The spectacle of the dragon so brilliantly lit was terrific. The barbarians beholding the unusual motion of the apparition were smitten with the greatest astonishment."

Then there is the story of the Count of Burgundy to whom it was proposed at the siege of a citadel near Naples to convey soldiers into the city by means of a cloud. The fate of this early aerial navigator, who, like some of his modern imitators, promised more than he could perform, was that the Count ordered him to be put to death.

Six years before William the Conqueror landed in England it is said that the monk Ollivier of Malmesbury made wings for his arms and legs. He jumped off a high tower, and was lucky enough to escape with no worse damage than a broken leg.

The first plausible record of flight concerns the Marquis de Bacqueville, who in the year 1742, according to Marey Monge (*Études sur l'Aerostation*), rose in sight of the assembled multitudes of Paris from his own residence on the Quai des Theatins and directed his course across the Seine towards the gardens of the Tuileries, whither he had signified his intention of proceeding. At first he appeared to advance with tolerable steadiness and facility. But when about half-way over he seemed to become unable to continue, his wings ceased to act in the manner necessary for his support, and he sank, falling on one of the floating machines belonging to the Parisian laundresses which line the arches of the Pont Royal, breaking a leg and sustaining internal injuries.

To us who imagine that the conquest of the air belongs to our own time this record, which speaks of "the assembled multitudes of Paris" witnessing the achievement of winged

flight, is a little disturbing. We cannot quite credit it; yet it is only right to point out that there are some authorities who believe that by dint of hard training and the specialisation of certain muscles and the contriving of the right kind of artificial wings a man might achieve winged flight. Early in the fourteenth century attempts were made to train children to use wings; and we are told that certain individuals learned to skim along the ground with a combined running and flying motion. If the Marquis de Bacqueville really did flutter off

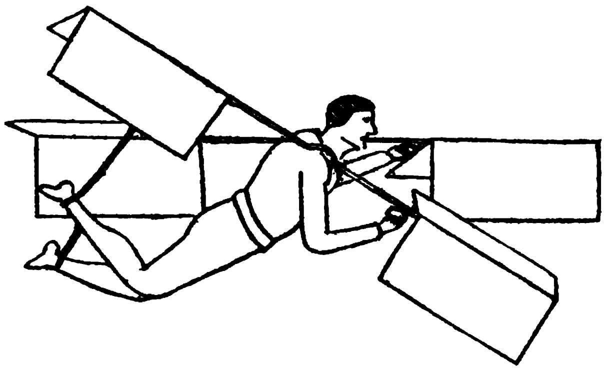


FIG. 1.—BESNIER'S FLYING APPARATUS.

The wings opened like a book on the downward stroke, and closed on being drawn upwards.

the ground for a few feet, what must have been his dreams and reflections as he lay recovering from his injuries? Certainly the world did not believe in him, and apparently the multitudes who saw him were unimpressed.

The contrivance used by the Marquis was based upon that of Besnier, a French locksmith, who about the year 1676 made a flying machine. The supporting surfaces were four collapsible planes suspended by two rods, one on each shoulder. The planes were of rectangular shape, and each was hinged in the middle like a book, closing with the upward movements and forming a wide flat surface on the down strokes. The two

front surfaces were moved by the arms, the two back ones by the feet. Besnier did not imagine that he could soar aloft with this apparatus, but only that he could fly down safely from an eminence. And this, it is stated, he and his pupils did on many occasions. It certainly appears that Besnier impressed his contemporaries; and what is very curious is the fact that the name of a pupil who is said to have achieved success with the Besnier machine was Baldwin, a name which occurs twice in modern times in connection with aerial adventure and inventions. An experimenter named Dante improved on the Besnier apparatus, and practised until he fell and broke his thigh.

Bartholemew de Guzman, a friar, in 1709 represented to the King of Portugal that he had invented a flying machine, and asked for an order prohibiting others from constructing similar machines. The King issued the following order:—

"Agreeably to the advice of my Council, I order the pain of death against the transgressor. And in order to encourage the suppliant to apply himself with zeal towards improving the machine which is capable of producing the effects mentioned by him, I also grant him the first Professorship of Mathematics in my University of Coimbra, and the first vacancy in my College of Barcelona, with the annual pension of 600,000 reis during his life. Dated the 17th day of April 1709."

Unfortunately for De Guzman his aims were regarded by the Church as heretical. Although he contended that his invention, by enabling men to soar in the skies, was not incompatible with divinity, a complaint was lodged against him and he was seized by the officers of the Inquisition. It is believed that he perished in gaol. What secrets died with him is matter for conjecture. His name should be preserved as that of a man who was publicly honoured as a conqueror of the air and then suffered martyrdom at the hands of an unsympathetic and incredulous conventionalism.

CHAPTER II

CURIOUS EARLY FALLACIES

LIKE other sciences that of aerial navigation has had its besetting errors, and even now when its light is shining with some clearness it may at any time be discovered that the full radiance has not yet been disclosed. Error in some conception of its principles probably still hinders its light. In other sciences recent investigations have removed long-cherished misconceptions, and it is not likely that the comparatively youthful science of aerial navigation enjoys immunity from such obstacles to progress. It is an edifying and educating task to examine the causes and histories of the more persistent errors, some of which are occasionally met with even to-day. Merely to state them reduces the danger of their recurrence.

Roger Bacon, who was born in 1214, peering with remarkably keen vision from the thirteenth century in which he lived towards the revelations made by science four or five centuries after his time, dwelt on the possibilities of aerial navigation. The ideas of that philosopher, who appears, as the result of his own researches, to have reinvented gunpowder and who undoubtedly knew of the properties of the lens, are worth recalling. Roger Bacon foresaw the time when "men would construct engines to traverse land and water with great speed and carry with them persons and merchandise." And again: "There may be made some flying instrument so that a man sitting in the middle of the instrument and turning some mechanism may put in motion some artificial wings which may beat the air like a bird flying." This great philosopher supposed the air to be an incompressible fluid, and thought that men would float on the

top of it as they can on the top of the sea. He appears to have originated the hollow-globe theory. He wrote: "The machine

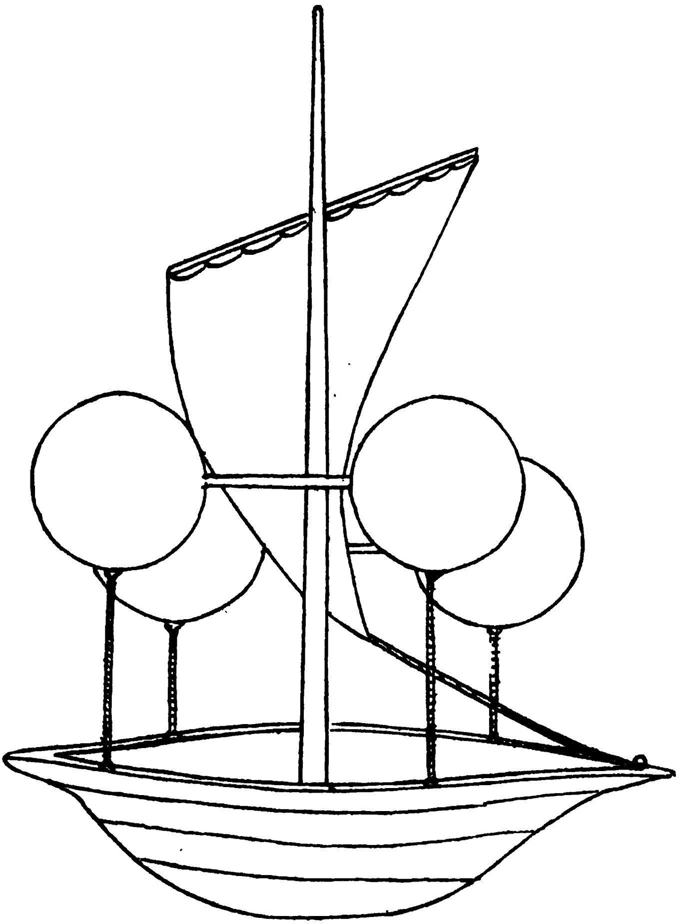


FIG. 2.—FRANCESCO LANA'S AIRSHIP.

must be a large hollow globe of copper or other suitable metal wrought extremely thin so as to have it as light as possible, and

it must be filled with ethereal air or liquid fire." Four hundred years later the Jesuit father, Francesco Lana, put forward a similar idea, suggesting an airship consisting of four hollow globes to be propelled and directed by oars and sails. One cardinal error involved in this idea was that the sail would be of any use in steering. As we know now, the only case when a balloon can obtain direction from a sail is when it has a trail-rope dragging along the surface of the ground or the sea retarding its progress and enabling a sail to obtain slight pressure from the air.

Lana proposed to use four hollow globes of copper, each 20 feet in diameter and so thin that they would weigh less than an equal bulk of atmosphere when they were exhausted of air. This was put forward in a book published at Brescia, in Italy, in 1670. The ascensional force of Lana's airship was given as 2650 lbs., of which 1620 lbs. would be the weight of the copper shells, leaving a margin of 1030 lbs. of lifting power. Lana thought that the spherical form of the balloons would enable them to withstand the pressure of the atmosphere. But as the total pressure on each sphere would be about 1800 tons, the possibility of resisting it with so thin a shell is more than doubtful. This absurdity of the vacuum airship is still perpetrated in books recently published on aerial navigation, the authors appearing to imagine that aluminium is strong enough and light enough for the purpose. Roger Bacon proposed to fill his hollow globes with something in the nature of "ethereal air or liquid fire." Evidently he knew more than seventeenth-century Lana and some twentieth-century authorities. Indeed, Bacon had a clear idea of the balloon, although he knew not the properties of gases.

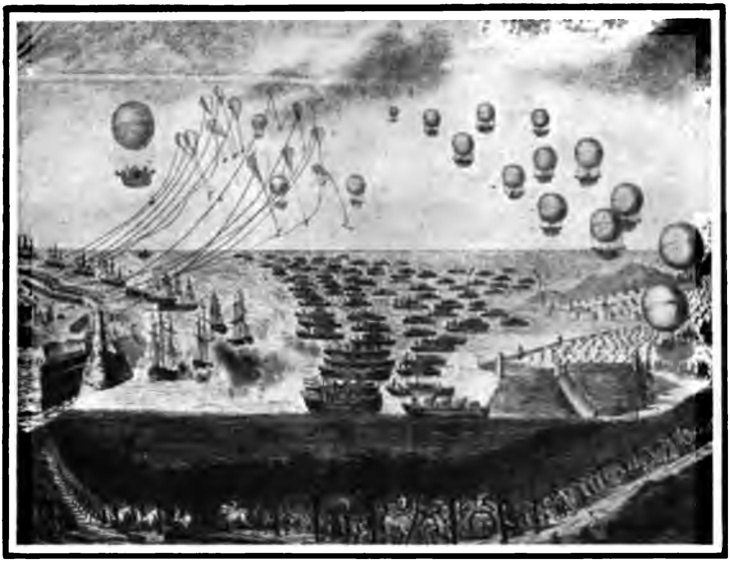
A somewhat fantastic idea that did not lack plausibility was that of Father Galien, of Avignon, who in 1755 published a book called *L'art de naviguer däns les airs ; amusement physique et géometrique*, in which he put forward a scheme for ascending mountains and enclosing the light, attenuated air found at

great altitudes in envelopes of canvas or cotton. He proposed to do this on a very large scale by bringing enough air down the mountain to carry several tons up again. It does not seem to have occurred to the reverend father that so much force would have to be expended in dragging this balloon down into the dense air near the ground that there would be no profit in the undertaking, nor did he say how the envelope could withstand the atmospheric pressure at the lower altitude.

The history of error in aeronautics up to the beginning of the present century is, indeed, the history of the larger part of the whole subject.

Brescia, the Italian town where Lana lived, is in a district that enjoys long aeronautical traditions. It was here that one of the first aviation meetings was held; and at Mantua, which is not far away, Leonardo da Vinci, who wrote the first treatise on mechanical flight, and demonstrated the principle of the parachute, lived and worked from 1487 to 1499. This versatile genius, who was painter, sculptor, military and civil engineer, and architect, drew the first technical design for imitation wings. In his machine the aviator was to occupy a horizontal position and work the flying strokes with his arms and feet by means of ropes passing over pulleys. The wings resembled those of the bat, and consisted of several parts which flapped together in the upward stroke and spread out on the down stroke. A tail surface was provided between the parted legs. Here is a paragraph from Da Vinci's work:—

"The bird should with the help of the wind raise itself to a great height, and this will be its safety; because although all the revolutions mentioned may happen, there is time for it to recover its equilibrium, provided its various parts are capable of strong resistance so that they may safely withstand the fury and impetus of the descent, being provided with the safeguards mentioned, with their ligaments of strong, tanned leather and their tendons of very strong, raw silk; and no one need trouble to use iron joints, because they split under the strain of a twist,



PROJECTS FOR THE INVASION OF BRITAIN
A French engraving during the Napoleonic wars illustrating an imaginary conquest of England by air, water, and a Channel tunnel.

THE BATTLE OF FLEURUS
A war balloon used by the victorious French on the 26th June, 1794. It performed valuable service.

or wear out, so that there is no need to trouble about making them."

Leonardo's manuscript on the "Flight of Birds" was written at Florence in 1505. It was among his papers at his death, and was left by his will to his companion Francesco Melzi. It accompanied many other Leonardo da Vinci manuscripts to Paris by the orders of Napoleon in 1796. At the general restitution of 1815 only the *Codex Atlanticus*, as it is called, was sent back to Milan. The treatise on flight remained at the Institut de France, was stolen, taken to Italy, bought by a Russian, and finally published in Paris in 1893.

Leonardo da Vinci's error was in the idea that a man could manipulate wings quickly enough to raise his own weight into the air. But this idea persisted for many centuries, and, indeed, has survived the criticism of Von Helmholtz, who, in 1872, demonstrated that man never could by his own muscular force and aided by the most ingenious mechanism raise his own weight into the air and sustain it there. To the possibility of a more extended use of the motorless glider that may conceivably come with a more complete knowledge of the atmosphere than we now possess reference will be made in another place.

Examining the attempts that were made by experimenter after experimenter to imitate flapping-wing flight, both without and with a motor, one finds an almost universal misunderstanding of the real action of the bird's wings. One of the commonest errors has been that the wings of a bird consist of an elaborate arrangement of valves which open on the up stroke and close on the downward. But the sparrow rises from the gutter to the eaves not by valvular action of the wings, but partly because the strong primary feathers at the tip of the wings give propulsion, their flexible rear edges causing their surfaces to move at an angle of inclination, the front edges being stiff. The closely packed secondary feathers near the shoulder of the bird act to some extent as sustaining planes. In insects the flexible membranous wings give propulsion, while the wing-cases often

act as planes. The flight of beetles, indeed, is not unlike that of the modern aeroplane.

The experiments of Joseph Berblinger, a tailor of Ulm, who wished to fly down from a scaffold by means of wing strokes, in May 1811, on the occasion of a visit of King Friedrich of Würtemberg, may be mentioned. The experimenter fell into the Danube. The experiment by Besnier was referred to in the first chapter, and no doubt there have been many others; and it is worth recalling that Fleyder, of Tübingen, in 1617 put forward the theory that man could fly like a bird if only he were trained to do so from his youth, thus producing an abnormal development of certain muscles; and this idea has been supported in modern times, as, for instance, by Von Wechmar in *Flugtechnik* in 1888. On the 15th of June 1902, Albert Schmutz leaped from one of the Seine bridges provided with wings, and was with difficulty saved from death by drowning.

Friedrich von Drieberg held that man has very great power in the muscles of the leg and could use these for flight. But this, of course, was Leonardo da Vinci's theory over again. As a curious instance of the persistence of error and the authority with which it is often promulgated, the work of J. A. Borelli, a Neapolitan scientist of the seventeenth century, may be mentioned. This author, in 1680, declared that artificial flight was impossible on account of the weakness of the breast muscles of the man as compared with his weight. This remained for two hundred years one of the accepted principles of the science, and it really seems to have hindered development, scientists taking for granted that birds possess great strength relatively to man, and that this is necessary for flight.

A very persistent belief is that a practicable flying machine can be driven by a propeller with a vertical thrust like the familiar helicopter toy. In practice no existing engine is powerful enough to lift its own weight in this fashion, but the fascination of the prospect of rising vertically from the

ground is sufficient to tempt inventors, in alliance, be it said, with company promoters, to produce schemes for this type of machine. A moment's thought will show how entirely useless such a machine would be even if it could be made to ascend. If the engine stopped it would descend vertically. The advantage of the aeroplane, indeed, is that it is the most economical method of using power for getting off the ground, and, in case of the sudden stoppage of the power, the machine descends in the way it goes up, namely, at a small gradient.

Another absurd idea is the quite common one in which the pilot, generally accompanied by a crew and passengers in a luxuriously appointed car, is suspended far below the machinery. This is claimed to secure automatic stability. Unfortunately, no engine could raise itself and such an apparatus into the air. These schemes are little better than instances of the wish being father to the thought, and are not worth dwelling upon at greater length.

In the department of dirigible ballooning error is very persistent. The cardinal errors of Lana and others have already been mentioned. Now we come to an absurdity which, unfortunately, is put forward with some show of authority in modern works on the subject. We are told over and over again that an airship can "tack" to and fro like a marine vessel to gain a point in an adverse wind which is too strong for it to drive directly against; and also and necessarily, indeed, that an airship is sometimes driven through the wind, which "sweeps across it from one side to the other." There have been so many opportunities of actual observation of aerial navigation that this mistake is unpardonable. Every one who has seen an aeroplane or a dirigible balloon in a side wind knows that to gain its object it moves crabwise. The stronger the wind the greater must be the angle of the aerial vessel to the direct line of its course. So that, in an extreme case, while an airship made for a point due east, its nose might have to be kept steadily pointing to the N.N.E. By attempting any sort of

zigzag course time would be lost and no advantage gained. The author found it necessary to emphasise this point when giving the Cantor lectures on Aeronautics before the Royal

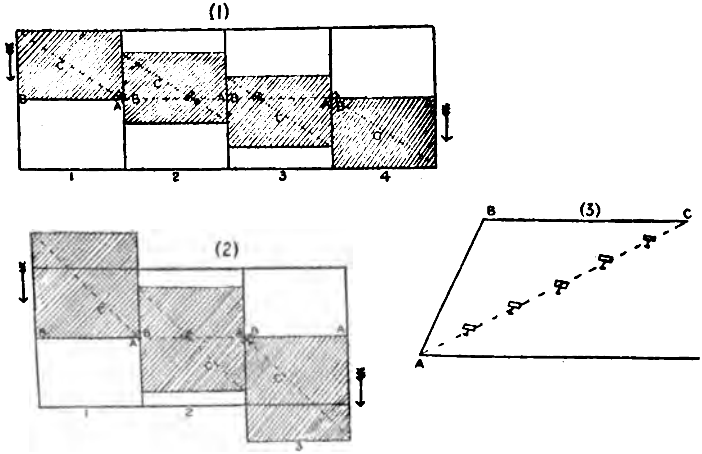


FIG. 3.—EFFECT OF WIND ON DIRECTION OF FLIGHT.

In 1 and 2, A is the starting-point and B the destination. The shaded portion is a body of air, *i.e.* the wind moving in the direction of the arrow. The diagonal line C is the path of the aeroplane with regard to the air. The dotted horizontal line is its path with respect to the earth. No 2 shows the effect of a stronger wind than number 1, *i.e.* a longer body of air passes in a given time. The aeroplane, therefore, has further to travel with regard to the air, and takes longer to arrive at B.

No. 3. Aeroplane (speed 20 miles per hour) sets course for B without allowing for the wind, which is blowing at 30 miles per hour from left to right. It is 40 miles from A to B, and 60 miles from B to C. In two hours, therefore, the machine instead of arriving at B finds itself at C.

Society of Arts in 1909, and to illustrate it by means of the accompanying diagrams. To repeat what I said on that occasion :—

"With regard to the sensation of 'wind' felt by aeronauts, this is only that due to the independent speed of the aerial craft. It will always be the same, whether it be a following

or a head wind, neither more nor less intense, because the surrounding wind is nothing but a movement of the atmosphere in which the machine or balloon is submerged. Relatively to the ground below, a dirigible balloon or an aeroplane may be going with the wind at 100 miles per hour, or against the wind making headway only at five miles an hour. If its engine be working at the same power in each case the speed of the vessel relatively to the atmosphere is the same. The envelope of a dirigible is only calculated to sustain the speed of which its engines are capable, and its stability depends upon a certain pressure of air not being exceeded.

"Bear in mind that wind is a body of calm air moving more or less rapidly. To the aeronaut wind does not exist. He is in calm: the earth is moving. A machine may be in a current of air moving, say, from west to east, at twenty miles per hour. With whatever speed it may be capable of, the airship can move freely about in that current. Obviously, if its speed be only twenty miles per hour, and its head be pointed to the west, while driving at full speed and actually moving through the air at twenty miles per hour, to the observer below it will seem to stand still. If the aeronaut desire to make a point due north, the balloon will drift to the east to exactly the distance covered by the wind in the time taken by the journey. It will have travelled with its bow pointing to the north, and the wind felt by the travellers will be from stem to stern. They will not have felt the west wind that has carried them out of their course, although it has had such an effect upon the direction of their vessel. If out of sight of earth and ignorant that a west wind was blowing, the aeronaut would not know that he was drifting out of his course, and would be astonished. Like a ferryman crossing a stream, the machine would have to head to the north-west to be sure of reaching its goal, and it would have no hope of doing that at all unless its own speed were superior to that of the wind.

"Imagine travelling with your own speed in addition to that

of a favourable wind. You are moving forward through the air at your own speed, but when you descend and moor to the ground you find that the wind is blowing at your back, and quite possibly the airship will be wrecked, unless you have plenty of men on the ground standing by to assist you. Indeed, you must turn your head round to face the wind on descending. The airship is constructed to bear strain that way, but even then there must be plenty of men to assist in the landing if there is a breeze.

"No analogy of any marine vessel except the submarine is of any use. For in the ship you have either got a sail giving you 'purchase' on the air, or you have the leverage of your keel or propeller giving you power against the wind.

"If you want to travel in a dirigible balloon which is capable of a speed of twenty miles an hour from London to Rugby against a wind of ten miles per hour you must see that you have enough fuel to take you to Liverpool, for you will have to travel through just as much atmosphere as on a calm day extends from London to Liverpool. If you had an airship capable of a speed of 100 miles per hour and wanted to go to Bristol on a day when there was a scarcely perceptible breeze of six miles per hour from the north, you would go out of your course exactly six miles in every hour that the journey occupied.

"As regards the personal experiences of the traveller in a dirigible balloon, draughts are caused by small eddies and waves of air that are not influencing the whole motion of the vessel; also a draught is sometimes felt in turning. Indeed, even in an ordinary balloon a draught is felt whenever the balloon is rising or descending, for then it always revolves.

"In practice, as a matter of fact, these conditions are slightly modified—modified, indeed, to so small an extent as to be scarcely appreciable—owing to the intermittent character of all air currents. Wind never blows with uniform velocity, and an aeroplane, having a certain degree of inertia, does not instantly

respond to the change of speed. The amount of inertia varies with different types of air craft."

Occasionally slight side puffs may be detected; but this is only when a turn is being made without banking the machine up on one side. She then drifts sideways, and if there be an uneven wind abeam it may be felt.

Erroneous ideas as to the danger to balloons from lightning are still common. Many people appear to think that if a balloon is struck by lightning there must be a terrible explosion. Yet nothing is more unlikely. An explosion would follow if by any chance a spark were applied to a mixture of gas and air such as is sometimes formed at the base of a balloon near the neck. Gas without the admixture of air is not explosive, and if a flame were applied to the interior of a fully inflated balloon it would simply be quenched. It is probable that if lightning could pierce the envelope of a balloon—a most unlikely contingency—it would not ignite the gas; and if it did, the gas would simply flare at the rent. No doubt the rent would quickly enlarge and the balloon would rapidly descend, but the occupants might reach earth safely. But danger to a free balloon of being struck by lightning probably scarcely exists. There is only one instance on record, when Captain Ulivelli was killed at Rome in 1907 in the presence of King Victor and Queen Elena, but the cause even in this case is doubtful; it is, however, supposed that the explosive mixture of air and gas at the base of the balloon became ignited. Very frequently balloons have been in the heart of thunderstorms and have not been injured by lightning.

The danger of electrical discharges from the atmosphere concerns chiefly a captive balloon, and it exists in fine as well as in stormy weather. Electricity of one kind deposited on the balloon discharges through the wire cable or the rope (if it be wet), or from the balloon to any building in close proximity. There have been a number of accidents to military balloons due to this cause, and in many cases soldiers employed at the earth-

end of the cable to a balloon or to an observation kite have been knocked down and badly hurt. Precisely what the danger is to a balloon is not known. It is possible that electricity of the positive quality collected in one stratum in the atmosphere may give rise to dangerous discharges when the balloon enters a stratum that is charged with negative electricity. But probably there is no danger unless the balloon be connected with the earth or is in very close proximity to buildings. In thundery weather, however, balloons are in great peril owing to the violent changes of temperature producing sudden changes in their equilibrium; and the fierce squalls of wind which are a common accompaniment of thunderstorms have in some cases caused disaster.

While on the subject of balloons it is profitable to point out that the Montgolfier brothers were not, as is commonly supposed, absolutely the first to conceive the possibility of obtaining ascensive force with a substance lighter than air. Mendoza (in *Viridario*) suggested that a wooden vessel placed "on the summit of an aerial superficies and filled with elementary fire will be sustained in that position till the gravity of the vessel becomes greater than the sustaining power of the fire it contains." Again, Albertus Magnus, in the twelfth century, in his work *De Mirabilibus Naturae*, says: "Take one pound of sulphur, two pounds of willow carbon, six pounds of rock-salt ground very fine in a marble mortar. Place, when you please, in a covering made of flying papyrus to produce thunder. The covering, in order to ascend and float away, should be long, graceful, well-filled with this fine powder." And we have already seen that Roger Bacon also had a somewhat hazy idea of this kind.

CHAPTER III

THE STORY OF THE MONTGOLFIERS

ALLOWING the utmost for the theories of balloons suggested in the vague and impracticable propositions put forward by Lana and Galien many centuries ago, we may still hold to the common belief that Stephen and Joseph Montgolfier were the inventors of the man-lifting balloon. Previously there had been a certain amount of experimenting towards this object. Hydrogen gas had long been known, although little had been ascertained about its character and properties. In 1766 Cavendish found that its weight was about one-seventh part that of air. Soon after, Dr. Black, of Edinburgh, suggested that "inflammable air," as it then was called, could raise a thin bladder into the air, and in 1782 Cavallo put the idea into practice and filled soap bubbles with the gas so that they floated upwards. Nothing came of these experiments however, but it was in that very year that the Montgolfiers found that they could lift heavy bodies into the air by the ascensive power of smoke.

The two brothers were members of an ancient paper-manufacturing family. One of their ancestors introduced paper into the Holy Land, and the father of the balloon inventors was the first to make vellum paper in Great Britain. The famous brothers resided in the town of Annonay, in Auvergne. The story goes that on a November night in 1782 they were sitting together over the fire and, while watching the smoke curl up the chimney, one of them exclaimed, "Why should not smoke be made to raise bodies into the air?" There may or may not be literal truth in this story, but in a paper read before the

Academy of Lyons, the elder brother stated that they owed their inspiration to reading a French translation of Priestly's *Experiments Relating to the Different Kinds of Air*, which was, he said, "like light in darkness." From that moment they conceived the possibility of navigating the air.

Their own trade gave them the idea of a suitable material with which to make experiments, and they made a large paper bag which they filled with smoke by holding it over a chafing-dish. The bag distended, became buoyant, and floated to the ceiling. While they were making this experiment, the widow of a neighbour who had had business transactions with them seeing smoke escaping from the room ran in and stood watching them. Noticing that they had some difficulty in holding the bag over the dish, she suggested that they should tie the dish on to the bag. They followed her advice, and found that it made their work much simpler. The same experiment was repeated in the open air, when the smoke-filled bag ascended to a great height. Then a bag of about 600 cubic feet capacity was made and filled with smoke, with the result that it broke away the strings holding it down and floated away to a great distance.

It must not be supposed that the brothers Montgolfier were under any delusion as to the reason for this phenomenon, or that they ascribed any particular virtue to smoke. They probably knew that it was the hot air that possessed the lifting power, and that the smoke was only an unavoidable circumstance of the experiment. They proceeded to make a linen and paper bag 35 feet in diameter and with a capacity of about 23,000 cubic feet. When filled this balloon rose to a height of 1000 feet and travelled a distance of a mile.

After this success they decided to give a public exhibition, and rumours of their wonderful discovery having already travelled abroad, enormous interest was aroused by the announcement that on the 5th of June the large balloon already made would be sent up into the air. Invitations to witness the experiment were sent to the State Assembly of Vivarais, then in

FLYING HOME AT DUSK

Tabuteau descending in a vol-plane on to Salisbury Plain, near Stonehenge, on a Bristol biplane.

session at Annonay, and on the appointed day an immense crowd assembled in the market-place, in the midst of which stood the two brothers and their assistants. The waiting crowd had eyes only for the swelling balloon, a huge ball tied down over a hole in the ground into which straw and wool had been thrown for the furnace. The furnace needed the services of two men only, but to hold the impatient balloon down took up the energies of eight assistants. The bag and its frame weighed 300 lbs. Most of the crowd were frankly cynical and refused, until they saw, to believe the declaration of the Montgolfiers that when the bag was sufficiently filled with hot air it would of its own accord ascend into the sky. Everything went on according to the programme, and at a given signal the balloon was loosed. At once it shot upwards, climbing higher and higher until its altitude was estimated at about 6000 feet. It travelled a mile and a half in a horizontal direction before it came to earth.

Great public excitement and enthusiasm was caused by the news of this event, and in Paris a subscription was raised to defray the cost of further experiments with "inflammable air." The manufacture of hydrogen gas was expensive. One thousand pounds of iron filings and 498 lbs. of sulphuric acid were necessary to fill a balloon of 22,000 cubic feet capacity. This an experimenter named Charles resolved to do, and this, by the way, was the first occasion on which a contrivance of the kind was called a "balloon." On the 23rd of August 1783, the filling of the new balloon commenced in the Place des Victoires. Bulletins were published daily as to its progress, but as the crowd grew to vast proportions the balloon was moved during the night of the 26th to the Champ de Mars. A description by an eye-witness was as follows: "No more wonderful scene can be imagined than the balloon being thus conveyed, preceded by lighted torches, surrounded by a cortège, and escorted by a detachment of foot and horse guards; the nocturnal march, the form and capacity of the

body carried with so much precaution; the silence that reigned, the unseasonable hour, all tended to give a singularity and mystery truly imposing to all those that were unacquainted with the cause. The cab drivers on the road were so astonished that they were impelled to stop their carriages and to kneel humbly, hat in hand, whilst the procession was passing."

The ascent was an imposing business. This occurred on the 27th of August in the presence of a vast concourse of people kept in order by thousands of troops. The event took place at 5 P.M., and was signalised by the firing of cannon. The balloon rose to a height of over 3000 feet in a few seconds, when it vanished into the clouds. After remaining in the air for three-quarters of an hour it safely descended in a field near Gonesse, fifteen miles distant. The astonishment of the villagers may be imagined. A contemporary writer described it as follows: "On first sight it is supposed by many to have come from another world; many flee; others more sensible think it an enormous bird. After it has alighted there is yet motion from the gas it contains. A small crowd gathers courage from numbers and approach by gradual steps, hoping meanwhile that the monster will take flight. At length, one bolder than the rest takes his gun, aims carefully within range, fires, witnesses the monster shrink, gives a shout of triumph, and the crowd rushes in with flails and pitchforks. One tears what he thinks to be the skin, and so causes a poisonous stench; again all retire; shame no doubt urges them on, and they tie the cause of alarm to a horse's tail, who gallops across the country tearing it to shreds."

The Government deemed it advisable at this stage to issue the following proclamation:—

"A discovery has been made which the Government deems it right to make known so that alarm may not be occasioned to the people. On calculating the different weights of inflammable and common air it has been found that a balloon filled with inflammable air will rise towards heaven till it is in equili-

brium with the surrounding air; which may not happen till it has attained to a great height. Any one who should see such a globe, resembling the moon in an eclipse, should be aware that far from being an alarming phenomenon it is only a machine made of taffetas or light canvas covered with paper, that cannot possibly cause any harm and which will some day prove serviceable to the wants of society."

As to the Montgolfiers, so highly were they esteemed that Louis XVI. issued the following "letter patent":—

"To the Sieur Pierre Montgolfier, December 1783:—

"Louis, by the grace of God King of France and of Navarre, to all present and to come, greeting:

"The aerostatic machines invented by the two brothers, the Sires Etienne-Jacques and Joseph-Michel Montgolfier, have become so celebrated, the experiment made before us on the 19th of September by the said Etienne-Jacques Montgolfier, and those that have followed, have had such success, that we have no doubt but that this invention will cause a memorable epoch in physical history; we hope also that it will furnish new means to increase the power of man, or at least to extend his knowledge.

"Persuaded that one of our chief duties is to encourage persons who cultivate the sciences, and to show the effects of our good wishes to those who succeed in enriching them by happy discoveries, we have thought that this ought more especially to draw our attention to the two enlightened naturalists who share the glory of the discovery.

"We have learnt that the Sire Pierre Montgolfier, their father, is of an ancient and honourable family, and that having received from his ancestors a paper manufactory situated at Annonay, in Vivarais, he has rendered it by his care and intelligence one of the most important in the kingdom, so that three hundred people are there employed. We are also informed that the said Sire Pierre Montgolfier was the first to make

vellum paper, and that in 1780 the States of Languedoc, wishing to imitate the Dutch manufacture, entrusted to him the commission, by which he gave so much satisfaction, that many manufacturers copied his productions. These circumstances relating to the Sire Pierre Montgolfier are sufficient to place him among those large manufacturers who by their zeal, their activity, and their talents, can hope to receive the most flattering and distinguished honour we are able to accord—that of being raised to the rights and prerogatives of the nobility. But what has caused us to bestow it at once on the Sire Pierre Montgolfier is, that it may be (both) a reward worthy of the labours of the father and of the beautiful discovery of aerostatic machines, entirely owing to the knowledge and researches of his two sons.

"For these causes, by our especial grace, full power, and royal authority, we have ennobled, and by these presents signed by our hand do ennoble the said Sire Pierre Montgolfier, and we have honoured and do honour him with the title of Squire; and we wish and it pleases us that he be enrolled and addressed, as we have enrolled and addressed him, Noble, at all times, together with his children and descendants, male and female, born and to be born in legitimate marriage; that they may and like him at all times and in all places be ranked as squires, and be enabled to arrive at all degrees of chivalry and other dignities, titles, and qualities, reserved for our nobility, that they shall be inscribed in the list of squires, and that they shall enjoy all rights, privileges, and prerogatives that are reserved to them. LOUIS."

The news of the discovery of the balloon swept through the world, and brought with it joy and jubilation. In England it seemed to excite envy and malice, for at that period there was little love lost between the two countries, and the people of each had the grossest misconceptions of the other. In the English periodicals of the time, claims were made that the

Montgolfier discovery was really due to English experiment and research. Again, when the news reached St. Petersburg and got to the ears of the aged scientist Euler, who had himself been experimenting towards the invention of an aerostat, it is said that he had a fit and died. He had, be it said, laboured under terrible physical affliction, and had been dictating to his sons a treatise on aerostatical globes. The news of the success of the Montgolfiers was, no doubt, a bitter disappointment.

Clearly the next step was the taking of a human being into the air by this new machine. Who would volunteer to risk his life in the cause of science? Pilâtre de Rozier volunteered, and by the end of November of 1783 a new balloon was built, 74 feet high, 48 feet in diameter. Two passengers could be taken in such a balloon, and the Marquis d'Arlandes came forward enthusiastically to share with De Rozier the honour of making the first balloon voyage. De Rozier made a few ascents with the balloon held captive, and then the daring experimenters took their seats in the car, each furnished with bundles of fuel to feed the furnace, which was contained in an iron brazier slung below. Each also was provided with a large wet sponge for use in case the balloon should catch fire.

The Marquis d'Arlandes said in his account of the voyage:—

"Our departure was at fifty-four minutes past one, and occasioned little stir among the spectators. Thinking they might be frightened and stand in need of encouragement, I waved my arm. M. de Rozier cried, 'You are doing nothing, and we are not rising.' I stirred the fire and then began to scan the river, but Pilâtre cried again, 'See the river. We are dropping into it.' We again urged the fire, but still clung to the river bed. Presently I heard a noise in the upper part of the balloon, which gave a shock as though it had burst. I called to my companion, 'Are you dancing?' The balloon by

now had many holes burnt in it, and using my sponge, I cried that we must descend. My companion, however, explained that we were over Paris and must now cross it; therefore raising the fire once more, we turned south till we passed the Luxembourg, when, extinguishing the flame, the balloon came down spent and empty."

The first men to ascend in a balloon had returned to earth safely. Two months later at Lyons an enormous balloon, 130 feet in height and capable of lifting 18 tons, ascended with seven passengers. At a height of 3000 feet the envelope developed a huge rent and descended rapidly. Fortunately, no harm was done.

CHAPTER IV

DEVOTED INVESTIGATORS

FOR a century after the invention of the balloon by the Montgolfiers there was no other practicable method of aerial travelling. The idea of any other method was only entertained by a few investigators who were regarded by their contemporaries as cranks and visionaries. The scientific scarcely troubled to argue the matter, and the well-informed were always able to point to an authoritative and definite denial of the possibility of flight made as long ago as 1680 by the Neapolitan scientist Borelli. For two hundred years after Borelli's time it was accepted as a fact that on account of the weakness of the breast muscles in man artificial flight was impossible. Borelli's influence prevented further development. Yet it was very curious that there were in existence all this time the remarkable drawings and suggestions of Leonardo da Vinci, which were only discovered and published for the first time towards the end of the nineteenth century. Borelli had assumed that the wings must necessarily be moved with the arms. Leonardo da Vinci, however, recognised that man has great power in the muscles of the leg, and his suggested flying machine was designed with that in view. As we shall see, Friedrich von Drieberg in 1845 independently urged the value of the leg muscles if artificial flight was ever to be possible.

All this would be beside the point, since mechanical flight without a motor has not yet proved practicable, but it will serve to illustrate the remarkable persistence with which the idea of flight was cultivated by a thin stream of enthusiasts during the first half of the nineteenth century.

Only one year later than the invention of the balloon, Gerard proposed a flying machine equipped with an engine. This very vague proposal is only referred to incidentally, but it is interesting on account of the suggestion that power was to be obtained in some way from escaping gases and the explosions of gun-cotton. Many futile attempts were made to guide balloons. In 1786 Testu-Bressy took oars up in a balloon, but, needless to say, he found them quite useless.

In the opening year of the nineteenth century General Resnier conceived the ambitious project of sending a French army corps to England through the air. He built an experimental flapping-wing machine with which he jumped off the ramparts of Angoulême. He fell into the river, but repeated his experiments. In the second attempt, jumping from an altitude of 200 feet he travelled 600 feet horizontally before reaching earth. But the aerial invasion of England was not even then practicable.

During these interesting events there was living in England a far-seeing genius whose investigations were from eighty to a hundred years in advance of their time. As a boy he was deeply impressed by the invention of the balloon, and from his early youth he showed a strong leaning towards scientific work, and especially towards the science of aerial navigation. The name of Sir George Cayley is now honoured by aeronauts all the world over, but to appreciate fully his achievements we have to remember that he was of noble descent, being the sixth baronet of his line, and that he lived in an age when it was very far from being the fashion for the nobility to devote themselves to any serious pursuit except the profession of arms. His knowledge of steam-engines enabled him early to point out the fallacy of the idea that power for aerial locomotion was available from that source. He demonstrated that no steam-engine would yield sufficient power combined with adequate lightness. This led to his invention of the air engine, and he seems clearly to have foreseen the gas-engine and even to have

had some idea of electricity as the necessary motor. He invented an arrangement for applying electric power to machinery, though it does not seem to have been put to any important use.

Most remarkable of all, however, was his suggestion for a dirigible balloon. Indeed, had his proposals been carried out a dirigible balloon might have hovered over the field of Waterloo and brought news of the approach of Blucher to the Duke of Wellington. In 1810 he stated that he could construct a balloon that should carry its passengers at twenty miles an hour. He seems to have been the first really to understand that vital principle of airship construction, namely, that assuming a cubical construction, the surfaces increase as the *square* of the diameter of the balloon, whereas the capacity to contain gas increases as the *cube* of the diameter. In other words, if you take two cubes, one with a diameter of 10 feet and the other with a diameter of 20 feet, and drive them through the air with equal speed, the resistance will be in exact proportion to the extent of the surface. Now the surface of the 20-foot cube is just four times as great as the surface of the 10-foot cube. It will, therefore, require four times the engine-power to keep up the velocity. But the quantity of gas contained in the larger cube is *eight* times greater than that in the smaller, hence it could take up the necessary engine-power and a substantial margin in excess. Cayley realised what even some modern authorities appear to ignore, that the larger the balloon the greater is its capacity for speed and altitude. This is very wonderful when we consider that he lived as long ago as the early part of the nineteenth century.

In the year of Queen Victoria's coronation he tried to establish an aeronautical society, but without success. He was returned to Parliament for Scarborough in 1852, but there is no record showing that he ever mentioned aeronautics in the House. In addition to his theories of dirigible balloons he mentions, in a remarkable and intensely interesting paper

published in *Nicholson's Journal* in 1810, an experiment he made with a gliding contrivance which had a surface of about

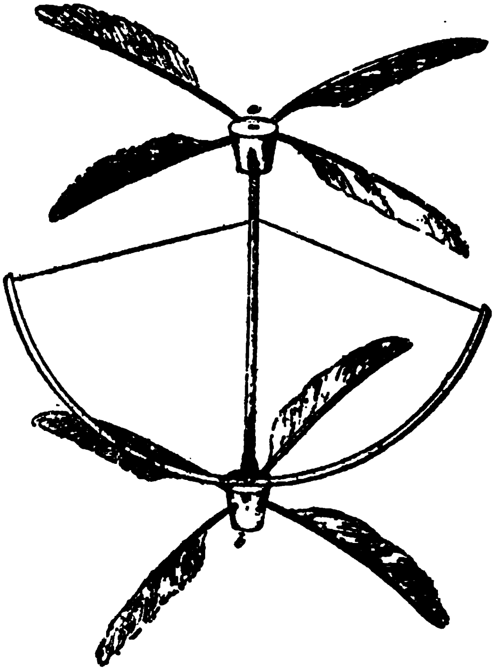


FIG. 4.—CAYLEY'S TOP.

Two corks, into each of which are inserted four wing feathers, so as to be slightly inclined like the sails of a windmill, but in opposite directions in each set. A round shaft is fixed in the cork *a*, which ends in a sharp point. At the upper part of the cork *b* is fixed a whalebone bow, having a small pivot hole in its centre to receive the point of the shaft. The bow is then to be strung equally on each side to the upper portion of the shaft, and the little machine is completed. Wind up the string by turning the flyers different ways, so that the spring of the bow may unwind them with their anterior edges ascending. Then place the cork with the bow attached to it upon a table, and with the finger on the upper cork press strong enough to prevent the string from unwinding, and, taking it away suddenly, the machine will rise to the ceiling.

200 square feet. He made this glide from the top of a hill

to the plain below, its gliding angle being about eight degrees. And, as any one can see who will take the trouble to read that paper through, Cayley had a very fair knowledge of the principles of plane flight. He made exhaustive experiments with the actual wings of birds, and gave much attention to gliding flight, not concerning himself with flapping-wing flight, which occupied other investigators.

The familiar helicopter toy or flying top attracted Sir George Cayley's notice, and in 1854 he sent to the secretary of the French Aerostatic and Meteorological Society the following description:—

"Mr. Cooper of the London University, so far as I know, was the first person who improved on the clumsy structure of the toy called the Chinese top, and I saw his, in company with Professor Wheatson, mounting, say, 20 or 25 feet. I made one at Brompton and sent it to a very ingenious mechanic and engineer, Mr. Coulson of Redcar, in this county, who made me one, of which this is an exact copy. It is the best I have ever seen, and will mount upwards of 90 feet into the air. It is scarcely necessary to describe this toy, as these rough drawings sufficiently explain the structure and dimensions of each part. It is spun like the common humming-top with a strong small cord coiled round the stem when within a suitable handle. The lower end of the stem is pointed, and enters half an inch into the lower hole in the handle so as not to allow the top part to touch the top of the handle."

It has been stated by a descendant of Sir George Cayley that he made a flying machine. The statement continues: "In this machine he inveigled his coachman, who jumped out on its leaving the ground and broke his leg and the machine. The engine employed was driven by a number of explosions of gunpowder, each in a cell of its own and discharged by a detonator."

Sir George Cayley, "the father of British aeronautics," died on December 15, 1857.

A Viennese watchmaker named Degen carried out in 1808 experiments with a flying machine in which he balanced the weight of the machine by a counterpoise which hung over rollers on a roof and, later, hung free in space by means of a small balloon. The balloon prevented any catastrophe; but no progress was made with a machine. A somewhat similar contrivance was proposed by Thomas Walker, of Hull,

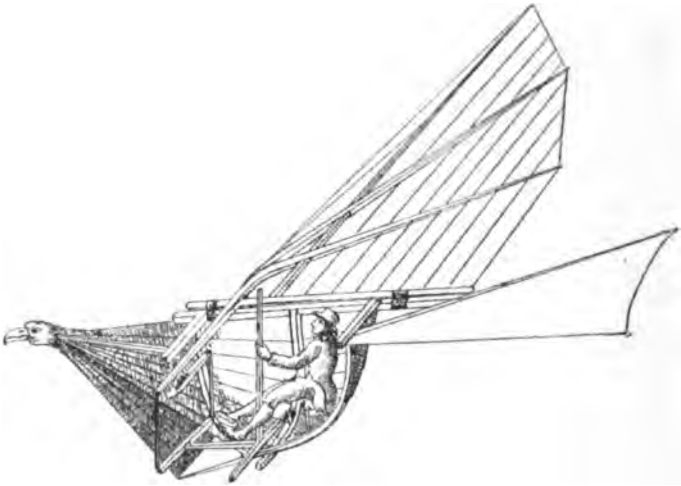


FIG. 5.—WALKER'S FLYING MACHINE.

in 1811, but without the balloon. Walker proposed the addition of a sail. He does not appear to have ever put it to the test.

The first man to make an aeroplane that flew was John Stringfellow, who was born on December 6, 1799, at Attercliffe, near Sheffield. He was brought up in the lace trade, and in 1820 he moved to Chard and set up a manufactory of his own. In the same town lived a young engineer named William Samuel Henson who was deeply interested in the science of flight. The two men came together and discussed the problems and set to work to design a machine.

Soon afterwards Henson had to go to London, but he and Stringfellow corresponded, while the latter, who was more interested in the engine part of the problem, began to build the series of light steam-engines upon which his reputation depends. Henson began his experiments with gliding models.

A company was formed in 1842 called the "Aerial Steam Transit Company," and an application was made in Parliament for a patent for "Certain Improvements in Locomotive Apparatus and Machinery for Conveying Letters, Goods, and Passengers from Place to Place through the Air, part of which Improvements are applicable to Locomotive and other Machinery to be used on Water and on Land." In his patent specification Henson explained as follow :—

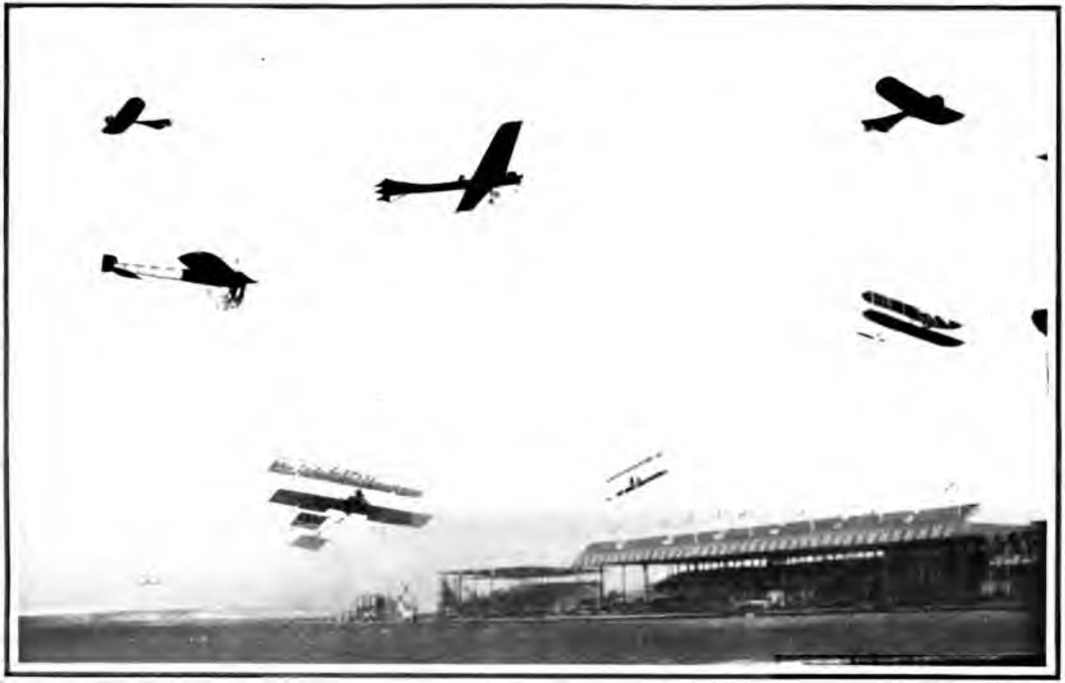
"If any light and flat, or nearly flat article be projected or thrown edgewise in a slightly inclined position, the same will rise on the air till the force exerted is expended, when the article so thrown or projected will descend; and it will readily be conceived that, if the article so projected or thrown possessed in itself a continuous power or force equal to that used in throwing or projecting it, the article would continue to ascend so long as the forward part of the surface was upwards in respect to the hinder part, and that such article, when the power was stopped, or when the inclination was reversed, would descend by gravity only if the power was stopped, or by gravity aided by the force of the power contained in the article if the power be continued, thus imitating the flight of a bird.

"Now, the first part of my invention consists of an apparatus so constructed as to offer a very extended surface or plane of a light yet strong construction, which will have the same relation to the general machine which the extended wings of a bird have to the body when a bird is skimming in the air; but in place of the movement or power for onward progress being obtained by movement of the extended surface or plane, as is the case with the wings of birds, I apply suitable paddle-

wheels or other proper mechanical propellers worked by a steam or other sufficiently light engine, and thus obtain the requisite power for onward movement to the plane or extended surface; and in order to give control as to the upward and downward direction of such a machine, I apply a tail to the extended surface which is capable of being inclined or raised, so that when the power is acting to propel the machine, by inclining the tail upwards the resistance offered by the air will cause the machine to rise on the air; and, on the contrary, when the inclination of the tail is reversed, the machine will immediately be propelled downwards, and pass through a plane more or less inclined to the horizon as the inclination of the tail is greater or less; and in order to guide the machine as to the lateral direction which it shall take, I apply a vertical rudder or second tail, and, according as the same is inclined in one direction or the other, so will be the direction of the machine."

The papers of the day published pictures of the machine flying over London, the Pyramids, and the sea, and published articles in which scientific men took sides for and against the idea. The first of the model flying machines which was driven by a small steam-engine was a failure owing to the fact that sufficient speed could not be attained to maintain flight. Stringfellow wrote of this failure:—

"There stood our aerial protégée in all her purity—too delicate, too fragile, too beautiful for this rough world; at least, those were my ideas at the time, but little did I think how soon it was to be realised. I soon found, before I had time to introduce the spark, a drooping in the wings, a flagging in all the parts. In less than ten minutes the machine was saturated with wet from a deposit of dew, so that anything like a trial was impossible by night. I did not consider we could get the silk tight and rigid enough. Indeed, the framework altogether was too weak. The steam-engine was the best part. Our want of success was not for want of power or



Topical Press

EIGHT AEROPLANES IN THE AIR AT ONCE AT BELMONT PARK, NEAR NEW YORK

sustaining surface, but for want of proper adaptation of the means to the end of the various parts."

After seven weeks of failures Henson declined to continue. He married, and went to America. Stringfellow carried on the work, and in 1846 began to make the model which was the first motor-driven aeroplane to fly. This historic machine was 10 feet in span, and 2 feet across in the widest part of the wing. The total carrying area was about 14 square feet. It was driven by two propellers. It was tried in a large hall early in 1848 with a special launching apparatus, and flew splendidly, rising gradually in the air and striking a hole in the canvas placed at the end of the hall to stop it.

Experiments that were very nearly successful, and which incidentally provided a number of sensational adventures, were begun by a French sailor named Le Bris in 1854. Le Bris had often watched the albatross during his voyages, and his imagination had been fired by the spectacle of that wonderful bird keeping pace with the swiftest ships and flying for long periods without flapping its wings. He killed an albatross and examined it. "I took the wing," he says, "and exposed it to the breeze, and lo, in spite of me it drew forward into the wind; notwithstanding my resistance it tended to rise. Thus, I had discovered the secret of the bird. I comprehended the whole mystery of flight."

Le Bris then decided to build an artificial bird capable of sustaining himself, and he designed a system of levers to control the wings. His artificial albatross had a body shaped like a boat, and was provided with two flexible wings and a tail. The body was 13½ feet long, and 4 feet wide at its broadest point, and it was made capable of floating in water. The wings had a spread of 23 feet each, so that the total span of the aeroplane was 50 feet, and it had a sustaining surface of 215 square feet. Le Bris seems to have made a very fair estimate of the amount of lifting power necessary for flight. The tail was hinged so as to move either sideways or up and

down. An ingenious device worked by levers imparted a rotary motion to the front edge of the wings and also permitted adjustment to various currents of wind. Le Bris was to stand upright in the car, his hands on the levers, and his feet on a pedal to work the tail. His belief was that given a strong wind he would rise in the air and reproduce all the movements of the soaring albatross without having recourse to flapping at all. His first experiment was at Trefeuntec, near Douarnenez. He chose a Sunday morning, taking advantage of a gentle breeze. In order to give the machine an initial velocity, of the necessity for which he was well aware, he placed the aeroplane on a cart and started at a good pace down the road. The bird was held in its place by a rope passing under the rail of the cart and terminating in a slip-knot tied to Le Bris's wrist so that the aviator could, with a jerk of the hand, loosen the machine and allow it to rise clear. He started off, holding the leading edge of the wings down to prevent them from rising. Assistants walking by the side of the cart held the aeroplane in position. At a signal they released their hold, and the pace of the car was increased. Then the inventor elevated the front edge of his machine, and after a brief delay the aeroplane lifted itself clear and with perfect balance, and Le Bris ascended to a height of 300 feet. But, unknown to the daring aeronaut, the end of the rope had become twisted round the body of the peasant who was driving the cart, and had lifted him also into the air. His weight balanced the contrivance. He was, indeed, a human tail to a huge man-lifting kite. But the unexpected ascent was too much for the nerves of the driver, who screamed and shouted with fright. The noise eventually reached the ears of Le Bris, who at once prepared to descend. He managed the descent very skilfully, and with no more damage than a slight breakage in one of the wings.

Le Bris was regarded as a hero in the district, although there was the usual amount of adverse criticism also. He was

too poor to mend his machine immediately and resume his experiments, and when at last he was able to make another ascent ill-fortune pursued him. He was caught in an eddy of wind and fell into a quarry, breaking his machine and one of his legs. This kept him in the background for many years, and it was not until 1867 that he was enabled by a public subscription to resume experiments with a second artificial albatross. The machine flew well, but Le Bris did not ascend in it. Then the inevitable accident happened, and the aeroplane was smashed to pieces. Le Bris retired from the pursuit of aeronautics, but served with honour in the Franco-German war of 1870.

About the same time that Le Bris commenced his experiments Letur designed a kind of dirigible parachute which he purposed releasing in mid-air from a balloon. When he made his experiment a high wind was blowing, and the balloon was driven along at a great rate, Letur hanging in his machine about 80 feet below the gas envelope. The balloonist did not hear Letur's shouts asking him to release him, and the parachute and its inventor were dashed into a clump of trees, and the experimenter was killed. This failure cannot of course be laid to the charge of any defect in the apparatus.

In 1875 a similar experiment was made by De Groof from Cremorne Gardens. A huge crowd assembled, and they saw the machine hanging from a balloon that was piloted by the aeronaut Simmons. De Groof rose seated in his aeroplane. When at a height of 3000 feet he gave a signal to the aeronaut, who instantly released him. Unfortunately, the inventor found that he was unable to work his wings, and he and his machine fell almost vertically and struck the pavement in Robert Street, Chelsea, the aeronaut being instantly killed. The balloonist on the same occasion had a narrow escape from death, for although on releasing the flying machine he let out a great quantity of gas from the balloon in order to compensate for the loss of the weight, the balloon shot up with fearful rapidity

so that Simmons lost consciousness. When he came to his senses he was rapidly descending, and was close to a railway line along which an express train was approaching. He actually fell on to the line, and would have been run over had not the engine-driver slowed up and some spectators hurriedly helped Simmons out of the way.

A curious machine was brought out by J. K. Smythies in 1860, which, despite its failure, showed that the inventor had studied the action of birds in flight, and realised the necessity for moving the weight carried in order to maintain equilibrium. He contrived to do this by means of a water-balance, and the whole construction was a clumsy and complicated system in which steam was to be employed.

In the same decade the interesting experiments of De Villeneuve were carried on. This scientist made no fewer than 300 working models, so that a portion of his house was full of them like a large aviary filled with experimental birds.

He made a large steam-model of a bat, and attempted to cause it to ascend with only the steam-engine on board. He mismanaged this trial, however, and brought the apparatus down too suddenly, with the result that it was smashed. It had attained a good height at the end of its cable, and the inventor declared that he only required a light motor and the problem of flight was solved.

In 1865 De la Landelle projected a huge airship consisting of aeroplanes surmounted by two masts, upon which revolved four sets of screws—a veritable "clipper of the clouds."

But it is quite impossible to mention all the projects for mechanical flight, and space can be given here only to two more. In 1868 Charles Spencer, at an exhibition of the Aeronautical Society, made some successful glides at the Crystal Palace on an areoplane consisting of one main plane, with a tail and a vertical surface for preserving equilibrium. A pair of small wings was attached to this machine.

An important advance in the way of aeronautics was

brought about by F. H. Wenham, who, from prolonged study of birds and of the principles of engineering and mathematics, came to the conclusion that the lifting power of a large carrying surface may be attained by arranging a number of small surfaces in tiers one over the other. He arrived at this result in 1859, and published the result of his inquiries in a paper read before the Aeronautical Society on June 27, 1866. This treatise is one of the classics of aeronautics: it contains almost every principle recognised to-day, but unknown or unexpressed then, on which the modern practice of mechanical flight is founded.

To explain, we observe certain invariable features in the wings of the gliding bird, and certain features that are not invariable. It is clear in the first place that the extended wings are always greater in span from left to right than they are in width. They vary from the albatross's, which are 14–1, to the lark's, which are 4–1. In other words, the "aspect ratio" of the albatross's wing is 14, that of the lark's 4; and the width of an aeroplane should never be more than about a fourth of its span, while in some actual machines it is not more than an eighth.

The planes are always greater in span than in width, but the proportion varies. They are always curved, but the amount of the curvature varies. The question of the proportion of the leading edge to the size of the aeroplane is one of the most important points. A plane 10 feet square will not lift so much as a plane 100 feet in span and 1 foot in width, although both have the same superficial area.

There is no doubt that Wenham could have made a flying machine capable of flight had he not lacked a light and powerful motor. He recognised this obstacle to his progress, and set to work to devise a light motor, and in doing so he actually made the first light gas-engine made in England, the forerunner of the internal combustion motor of the present day. It is true that a machine of the kind had been made by

Lenoir some years before, but Wenham's was an original, independent invention, and at all events it was the first application of the internal combustion motor to aerial navigation. Wenham's paper on "Aerial Locomotion" established in the first place that the effective sustaining power of inclined planes propelled through the air is limited to a narrow front portion, and that, therefore, great breadth of surface from front to back

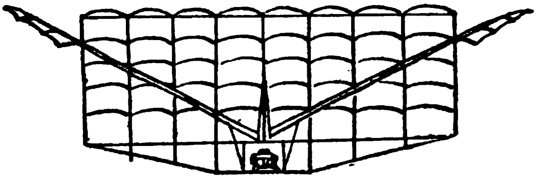


FIG. 6.—WENHAM'S GLIDER. VIEW FROM REAR.

Wenham discovered the use of superposed planes. The winged rudder propellers were worked by the legs of the aviator. No actual flight was achieved with this machine.

is wasted. Then he showed that a great length of leading edge could be obtained by having a series of small narrow planes one over the other, and further he demonstrated that flight does not require an excessively light machine, as was supposed, but that within limits they could be made strong and durable.

The work of the more modern investigators will be considered in a later chapter, wherein the researches and adventures of Lilienthal, Pilcher, and others will be narrated.

CHAPTER V

SOME BALLOONING ADVENTURES

DURING most of its history ballooning has been a much-ridiculed pastime, and indeed it has been left chiefly to public performers and showmen. To only a small degree will this lack of dignity be possible with flying, for mechanical flight is recognised as a progressive science worthy of the attention and devotion of serious men. Ballooning was long ago perceived to have reached its best; the balloon would ever be a helpless aerostat at the mercy of the wind, and only of occasional value for military and surveying purposes.

Yet the history of ballooning teems with exciting incidents, from which, however, only a small selection can be made in this book if due attention is to be given to dirigible ballooning and to flying machines.

The idea that ballooning is a dangerous pastime in itself cannot be entertained if one considers the small number of fatalities as compared with the number of ascents. In that fine aeronautical classic, *Astra Castra*, Hatton Turnor gave the names of the first 500 aeronauts, and of these only ten are marked with an asterisk to signify that they lost their lives. Here are the names of the ten first victims:—

Pilâtre de Rozier, Professor of Natural Philosophy, killed at Boulogne, 1785.
Romaine, killed at Boulogne, 1785.
Count F. Zambeccari, killed at Boulogne, 1812.
Olivari, killed at Orleans, 1801.
Mosment, killed at Lille, 1806.
Madame Blanchard, killed at Paris, 1819.

Bittorf, a mechanic, killed at Mannheim, 1812.
Sadler, killed at Bolton, 1824.
Lieutenant Harris, R.N., killed at London, 1850.
Cocking, in a parachute descent, killed at London, 1846.

Readers may be interested in having before them, for future reference, a list of the other fatalities of aerial navigation until the end of the last century:—

1840. Letur, a flying man, killed in London.
1847. Emma Verdier, found asphyxiated in the basket of balloon.
1850. Goulston, in America.
„ George Gale, at Bordeaux.
1854. Arban disappeared in the Pyrenees.
1858. Deschamps, in France.
1863. Donaldson and Grimwood, in America.
1873. La Montaine, America.
1874. De Groof, flying man, killed at Chelsea.
1875. Crocé-Spinelli, and Sivel asphyxiated at height of 26,000 feet.
1876. Triquet, junior, killed at Issy.
1879. Petit, at Mans.
1880. Charles Brest, drowned in the Mediterranean.
„ D'Armentieres „ „
1881. W. Powell, disappeared at sea.
1883. Laurens, at Philadelphia.
„ Mayet, at Madrid.
1885. William Clarence, at Charleston, Ohio.
„ Jules Eloy, drowned.
„ Gower, drowned in the Channel.
1887. Mangot „ „
„ L'Hoste „ „
1888. Simmons, at Waltham, Essex.
„ Vandegrift, drowned (America).
1889. A Belgian drowned in the Channel.
„ Strut, in America.
1891. George Higgins, at Leeds.
1891. A French aeronaut lost in the Channel.

1892. Capt. Dale, at the Crystal Palace.
„ Shadbolt „ „
„ Capt. Whelan, at Shrewsbury.
1893. Charbonnet, at Turin.
1896. Lilienthal.
1897. Wolfert and his assistant, at Berlin.
1900. Pilcher.

The list takes no account of at least four of the French balloonists and their passengers who were killed or lost after escaping out of besieged Paris in 1870.

The first balloon ascent in Great Britain was by James Tytler in 1784. In the *London Chronicle* of August 27th is published the following letter from a correspondent to that journal:—

"EDINBURGH, *August* 27, 1784.

"Mr. Tytler has made several improvements upon his fire-balloon. The reason of its failure formerly was its being made of porous linen, through which the air made its escape. To remedy this defect, Mr. Tytler has got it covered with a varnish to retain the inflammable air after the balloon is filled.

"Early this morning this bold adventurer took his first aerial flight. The balloon being filled at Comely Garden, he seated himself in the basket, and the ropes being cut he ascended very high, and descended quite gradually on the road to Restalrig, about half a mile from the place where he rose, to the great satisfaction of those spectators who were present.

"Mr. Tytler is now in high spirits, and in his turn laughs at those infidels who ridiculed his scheme as visionary and impracticable. Mr. Tytler is the first person in Great Britain who has navigated the air."

Lunardi's famous ascent from London took place a few weeks later. While the aeronaut hovered over London the

King was in conference with his principal ministers, and his Majesty, learning that he was in the sky, is reported to have said to his councillors, "We may resume our own deliberations at pleasure, but we may never see poor Lunardi again!" On this it is further stated that the conference broke up, and the King, attended by Pitt and other chief officers of State, continued to view Lunardi through telescopes as long as he remained above the horizon.

The public Press paid a worthy tribute to the hero of the hour, and one last act of an exceptional character was carried out in his honour and remains in evidence to this day. In a meadow at Standon, near Ware, stands a rough stone now protected by an iron rail. It marks the spot where Lunardi landed.

In the *Observer* of September 30, 1910, appeared the following account, reprinted from the issue of the same newspaper of September 30, 1810:—

"Mr. Sadler's ascension in a balloon at Bristol took place on Monday at a quarter past one. It was his intention to have been accompanied by his daughter; but from the state of the wind on Monday, he was so firmly persuaded the course of the balloon would be towards the sea, that he resisted her entreaties, and her seat was taken by Mr. Clayfield, of Bristol. Near 80,000 persons assembled to witness the ascension; and very soon after the cords were separated the balloon moved with extraordinary velocity towards the coast of Wales; but when it had attained a very considerable altitude, a strong current of air blew it back on the coast of Devon. The aeronauts in the management of the balloon encountered considerable difficulty, and both became at last nearly exhausted. At a quarter past four o'clock in the afternoon, the balloon was observed to descend with astonishing precipitancy into the sea, six miles from Lynmouth, on the North Devon coast, and a boat was immediately sent off to its assistance. The voyagers were brought to shore in a state of extreme fatigue, and Mr. Sadler was unable to stand

from having been some time in the water before the boat could reach the balloon. They were both provided with life-preservers, and were in consequence not afraid of being drowned."

While the English Channel has been crossed over by balloon scores of times and the North Sea has frequently been traversed, few aeronauts have braved the perils of the Irish Sea.

From the same paper of April 29, 1810, we take the following paragraph:—

"Professor Robertson, on the 1st instant, made his thirty-third aerostatical voyage at Berlin, and after sustaining much adverse weather, came down to safety near Spandau. Their Majesties the King and Queen of Prussia honoured his ascension with their presence."

While we are concerned with the pioneers of ballooning, a few lines may be spared to record the fact that the first woman to ascend was Madame Thible, who went up in a balloon from Lyons in 1784, and the first to ascend in England was Mdlle. Simonet in 1785. The first Englishwoman to make an ascent was Mrs. Sage.

A great adventure was the first crossing of the English Channel by balloon, the sensation it created being equal to that caused 124 years later when Blériot flew across the Straits on an aeroplane. Jean Pierre Blanchard was the first balloonist to dare the crossing. He had previously made a number of aerial voyages in company with Dr. Jefferies, an American; and these were the two who took their seats in a balloon and ascended from Dover Cliffs on the morning of January 7, 1785, Blanchard being in command of the expedition. The voyage nearly terminated disastrously, for before they had left the sea behind them the balloon showed a determination to descend, and was scarcely prevented from doing so by the sacrifice of everything movable, including the outer garments of the aeronauts, books, anchors, and cordage. However, they managed to clear the French coast and descended in the Forest of Guines, near Calais. Blanchard was honoured by a special summons from

the King of France, who presented him with 12,000 livres and a pension of 1200 livres a year. The car of the balloon is preserved at Calais.

Pilâtre de Rozier was the next to essay a cross-Channel voyage, and he desired to do it from the French side. He was anxious also to make an experiment the nature of which was truly amazing, and fills us with admiration for the courage that must have been necessary to put it into effect. At this time it should be remembered that there were two kinds of balloons in use, the Montgolfier or hot-air balloon and the gas-filled balloon. That on which Blanchard and Jefferies crossed the Channel was filled with hydrogen. The advantage of the hot-air balloon was its small cost and its independence of gas-making plant. On the other hand, a hot-air balloon must be made much larger than a gas-balloon to carry the same weight. It was, further, argued that a gas-balloon was in danger from lightning. The question of balloons and lightning, by the way, is discussed in Chapter II. De Rozier designed a balloon combining both the hot-air and the gas principles, and called it the Charles-Montgolfière. He found a friend, Romaine, willing to accompany him in this extraordinary composite balloon. The Marquis de Maisonfort was anxious to go, but de Rozier could not give him a seat in the car. The ascent of the balloon was watched by thousands of people, and for half-an-hour all went well, when it was seen that the balloon had burst into flames and was falling. Both of the balloonists were killed. A monument close to Boulogne marks the scene of the disaster, and the story is perpetuated also on the inn-signs and names of cafés in the neighbourhood.

During the war between France and Austria in the closing years of the eighteenth century, Jacques Garnerin designed the first effective parachute. Early in the war Garnerin was taken prisoner by the Austrians, and spent three years in the fortress of Buda in Hungary. While in confinement he conceived a novel method of escape. He worked out the necessary

THE AERIAL OCEAN

An attempt to illustrate the motion of the air over uneven country. The aerial navigator becomes experienced in the ways of the invisible fluid in which he directs his machine.

calculations for a man-sustaining parachute based on the resistance of the air to large surfaces and the acceleration of movement of falling bodies. But it was not until his return to France that he put his invention to use. In the programme of his first descent in a parachute in October 1797 he wrote: "The love of liberty so natural to a prisoner gave rise to many projects to release myself from the rigorous detention. To surprise the vigilance of the sentries, force walls 10 feet thick, throw myself from the ramparts without being injured, were schemes that afforded recreation." The experiment was made from the Park of Monceau. On attaining an altitude of 6000 feet Garnerin cut the cord that attached him to the balloon, which ascended till it exploded, whilst the parachute with him hanging below it rapidly descended. We cannot withhold admiration from the man who first trusted himself to a parachute, and even to this day, with the example of scores of previous parachutists who have made thousands of safe descents, it requires some courage. The spectators saw Garnerin's parachute oscillate in great sweeps, and many women fainted. However, says a contemporary account, the citizen Garnerin descended on the plain of Monceau, got on horseback immediately, and returned to the park in the midst of a crowd who loudly testified their approbation of the talent and courage of the young aeronaut. Garnerin made a number of ascents in England, and on one occasion his balloon took him from Chelsea to Colchester, a distance of sixty miles in forty-five minutes. Once he descended in a parachute from a height of 10,000 feet. Almost without exception the earlier generation of aeronauts were young men. De Rozier was twenty-eight when he was killed.

One of the most tragic incidents in the history of aeronautics was the result of the experiment by Henry Cocking in 1837 in a new form of parachute. Cocking's object was to make a parachute that would not sway from side to side during its descent. It is, by the way, with the same object that an opening is made

in the centre of a parachute through which a stream of air can pour. Properly to understand Cocking's experiment it may be worth while to consider the question of parachute design. Garnerin's parachute had a diameter of 23 feet. The oscillations were so great with this parachute that at the end of the swing Garnerin was on a level with the centre of his apparatus. Frau Poitevin used a parachute 39 feet in diameter. At the present day it is usual to make parachutes capable of sustaining the weight of about 200 lbs. The usual diameter is about 39 feet when flat, and when arched in the manner in which they descend the chord of the arc is from 30 to 32 feet. The car hangs about 20 feet below. A parachute descends at about the rate of one mile in twenty-five minutes, although at times the descent has been much more rapid. Frau Poitevin took, it is said, forty-three minutes to descend from a height of 5500 feet. Henry Cocking's idea was plausible enough, but the manner in which it was put into execution was very careless, and his calculations were extraordinarily slipshod. His idea was to use an inverted parachute. Now it is quite clear that the resistance to the air of such a parachute is very much less than when the concave side is underneath making a great cushion of air in its descent. It is quite certain that Cocking did not give a large enough diameter to his parachute, and that, therefore, it would in any case have fallen with great velocity. Monck Mason in a letter in the *Morning Herald*, on the day preceding the venture warned Cocking against the danger. He said: "I have no hesitation in predicting that one of two events must inevitably take place according to the special nature of the defect which may happen to be predominant. Either it will come to the ground with a degree of force we have before shown to be incompatible with the final preservation of the individual, or should it be attempted to make it sufficiently light to resist this conclusion it must give way beneath the undue exercise of the forces it will necessarily develop in the descent." As we shall see, the latter is precisely what happened; but before describing Cocking's experiment I

should like to point out that it has a relationship to a feature in the design of certain aeroplanes. Some machines, for instance the "Antoinette," are made with the planes inclining upwards to right and left from the centre of the machine in the form of a shallow V. The object of this is to obtain stability in flight. The reader is referred to Pilcher's explanation on page 89. But it is necessary to make a machine so designed with a much larger span than one with straight planes or with planes arched.

Cocking's ascent took place in July 1837. Green was the balloonist, with whom travelled Spencer. A vast crowd assembled in Vauxhall Gardens and in their vicinity. Just before the ascent Cocking said that there was no danger to him, although there would be some peril to the balloon when relieved of his weight. The proprietors of the gardens themselves urged the inventor not to make the experiment, but soon after 6 P.M. the balloon ascended with the parachute containing Cocking suspended below. Previous to starting, 650 lbs. of ballast had to be discarded to gain buoyancy sufficient to lift Cocking and his apparatus. A further 100 lbs. at the last minute had to be ejected owing to the sudden cooling of the evening air condensing the gas. The ballast, by the way, was passed out through a tube through a hole in the parachute, but on leaving the earth the parachute oscillated so much that the tube was torn away, and the aeronauts above had to make up their ballast in small parcels and throw them, as occasion required, clear of the contrivance suspended below.

Cocking had stipulated for an elevation of 7000 feet, but it was found that only 5000 feet could be reached, at any rate before darkness set in. This would have been quite sufficient for the purpose, and Cocking said that he would make the descent, and asked the aeronauts where they were. Spencer replied that they were over Greenwich. What ensued is related by Green:—

"I asked him if he felt quite comfortable and if the practical trial bore out his calculation. Mr. Cocking replied, 'Yes;

I never felt more comfortable or more delighted in my life'; presently adding, 'Well, now I think I shall leave you.' I answered, 'I wish you a very good-night and a safe descent if you are determined to make it and not use the tackle' (a contrivance for enabling him to retreat up into the balloon if he desired). Mr. Cocking's only reply was, 'Good-night, Spencer; good-night, Green.' Mr. Cocking then pulled the rope that was to liberate himself, but too feebly, and a moment afterwards more violently, and in an instant the balloon shot upwards with the velocity of a sky-rocket. The effect upon us at this moment was almost beyond description. The immense machine which suspended us between heaven and earth, whilst it appeared to be forced upwards with terrific violence and rapidity through unknown and untravelled regions amidst the howlings of a fearful hurricane, rolled about as though revelling in the freedom for which it had long struggled. . . . During this frightful operation the gas was rushing in torrents from the upper and lower valves, but more particularly from the latter, as the density of the atmosphere through which we were forcing our progress pressed so heavily on the valve at the top of the balloon as to admit of but a comparatively small escape by this aperture. At this juncture, had it not been for the application to our mouths of two pipes leading into an air-bag with which we had furnished ourselves previous to starting we must have been suffocated."

Green and Spencer eventually reached earth in safety near Maidstone, knowing nothing of the fate of their late companion. As to the fate of the parachute, a writer in a newspaper of the time says:—

"I was looking at the balloon with the parachute as it drifted steadily before a gentle wind and rose very slowly. After it was first pointed out to me the parachute seemed to float without any oscillation and to hang perpendicularly under the balloon. Shortly afterwards the balloon itself was slightly agitated, and was inclined considerably more to one side than

when I first saw it, and the parachute did not appear to hang so perpendicularly as at first. While I was referring this to the balloon rising perhaps into a stratum of air with a somewhat greater velocity than the one it was leaving, the balloon and parachute adjusted themselves into their first position and floated with as steady and gentle a motion as before. In an instant afterwards I observed the balloon shooting upwards with great velocity and the parachute falling with great rapidity. . . . For a few moments the parachute descended so beautifully and preserved its position so steadily, notwithstanding its fearful motion, that I thought it would reach the ground in safety. . . . It then seemed to lean a little to one side. It was not horizontal. It remained for a moment or two in this position all the while it was descending rapidly. It then fell as it were to the opposite side, but with a quicker motion. . . . It now oscillated several times quickly; a sort of flapping motion was then perceptible, and the parachute appeared lessened in diameter. It then apparently turned over, and at this moment something fell out of it at a great height which, for the instant I could keep it in sight, did not fall much faster than the parachute. The parachute again turned over, and to me and some others standing near it disappeared for the twinkling of an eye, and in the succeeding instant it was seen to have changed its flattish circular form to that of a long body like an umbrella partially opened or, more correctly perhaps, to a balloon very much collapsed and descending with a great velocity. Some trees intervening prevented my further observation. I made my way through the fields in the direction in which I had seen it falling, and as I reached a spot at a little distance from where it fell I saw the lifeless body of the unfortunate gentleman placed on a hurdle to be conveyed by some farm labourers to an inn at Lee." During the fall the basket with Cocking in it broke away from the parachute and reached the earth first.

CHAPTER VI

BALLOONING ADVENTURES (*continued*)

GREEN'S ballooning experiences brought him many adventures, one of which may be briefly narrated. On the 5th of July, 1850, he, with some companions, ascended late in the evening from Vauxhall in the great Nassau balloon. They reached an altitude of 20,000 feet, and were for half-an-hour above the clouds. On descending to ascertain their locality, they found themselves over the Thames estuary making for the Nore sands. A vessel being in sight, Green brought the balloon down to the water two miles north of Sheerness. The strong wind which was blowing caught the half-inflated balloon the moment the car was in the water and carried it over on its side, sweeping it along much too rapidly for any vessel to overtake. Fortunately the balloon anchor became entangled in a sunken wreck. Boats put out to the rescue from the land and from H.M.S. *Fly*, and the aeronauts were rescued; but the balloon itself in the wind that was blowing was far too dangerous an object to approach, and at Green's suggestion, therefore, bullets were fired into the silk, and the gas was expelled.

The worst danger of ballooning for many years was the dragging along the ground after the descent. The ripping-panel now in general use reduces this to a minimum. This ripping-panel is a huge rent extending from the hemisphere nearly to the summit of the balloon, and held together temporarily for gas-holding purposes. It is lightly stitched throughout its length, and from the top a cord passes down through the interior of the balloon to the basket, where it is

safely secured out of the way and only for use at the proper moment. The cord is distinguished by its colour, so that there is no possibility of confusion with the ordinary valve-line.

To prevent dragging, Lieutenant Harris, R.N., experimented in 1824 with his own invention, consisting of a large hinged upper valve having within it a smaller valve of the same description, his idea being that the larger opening might be used for the rapid deflation of the balloon on reaching earth. Lieutenant Harris took with him a young lady, Miss Stocks; and the day being very favourable, he left the balloon anchor behind. The balloon showed a marked tendency to descend, and, indeed, the first ascent was a failure. Then, after the discharge of much ballast, they went up again; but very soon the balloon again rapidly descended. Miss Stocks afterwards related that Lieutenant Harris became very anxious. She heard two loud reports in the balloon, and Lieutenant Harris said he was afraid it was bursting, upon which the lady fainted and knew no more until she found herself in bed. The balloon was seen to fall with great velocity, breaking the head of an oak tree and then striking the ground. Lieutenant Harris was picked up dead.

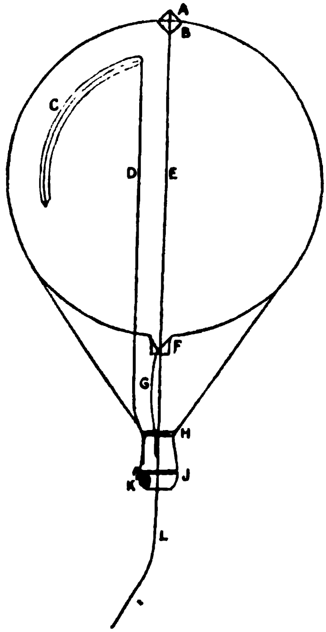


FIG. 7.—PARTS OF A BALLOON.

A, the valve; B, the valve-springs; C, the ripping-panel; D, ripping-cord; E, valve-line; F, neck; G, neck-line; H, hoop; J, basket; K, grappler; L, trail-rope.

It is probable that the valve-lines were made taut at the

hoop of the balloon when the inflation was finished and the balloon was full. Afterwards, when the quantity of gas in the balloon was diminished and the shape of the envelope became elongated, the line so strained and tugged at the valve that it finally opened it.

The fate of some balloons is unknown, although their disappearance has, in most cases, been due to being carried out to sea. There have, however, been one or two exceptions in addition to the well-remembered tragedy of the loss of Andrée, which is related in Chapter IX. Some day the decaying remnant of a balloon and the skeletons of those who occupied its car may be found lying in some mountain crevice in the Arctic, and definite knowledge may be obtained as to the fate of the lost explorers.

In recent years a balloonist named Bellamy ascended alone from the Crystal Palace. He was seen to pass the coast, and his balloon even then lacked buoyancy. He was never heard of again. On September 14, 1909, the balloon "Mariposa" ascended from Valencia with Captain Martinez, who had previously made over 250 ascents, so that inexperience can scarcely have been to blame for the fact that the balloon never returned. And another instance was provided by the balloon "Luna" in December 1909. Some weeks after its ascent a deflated balloon was seen by a fisherman in the Baltic, but it was never recovered, and the fate of the aeronauts can only be assumed. On November 13, 1910, a balloon ascended at Essen with three aeronauts, Lange, Remmeler, and Zimmermann, and was never heard of again.

Looking further back we come to the strange disappearance of Arban, an experienced balloonist who, in 1849, passed through the air over the Alps. Describing one of the scenes he witnessed during the night in Switzerland, Arban wrote: "Snow, cascades, and rivers were all sparkling under the moon, and the ravines and rocks produced masses of darkness which served as shadows to the gigantic picture." Arban

made an attempt to cross the Pyrenees by balloon in 1854, but he never returned.

The principal case of this kind, and one in which Great Britain is immediately concerned, was the loss of Walter Powell, M.P. for Malmesbury. Powell was an enthusiastic aeronaut, possessing his own balloon and his own gasworks. His last ascent was made on December 10, 1881, in the War Office balloon "Saladin," in company with Captain Templer and Agg-Gardner. The object of the ascent was to make meteorological observations. The balloon passed near Exeter, and then it was thought prudent to descend rather than approach too near to the sea. However, a different wind carried them back to Bridport, near which place they endeavoured to make a hasty descent. The wind meanwhile was rapidly carrying them towards the sea, and it appeared very doubtful whether they would alight on water or on land. They touched earth, and the balloon immediately began dragging towards the water. Captain Templer and Gardner jumped out, the latter at the expense of a broken leg; but before Powell could alight the balloon, relieved of the weight of two men, shot upwards and away. There were reports afterwards that it had been seen off the coast of Spain, but it was never recovered. It is not unlikely that the loss of so much weight may have sent him up to so great a height that the aeronaut was suffocated.

During the siege of Paris sixty-five balloons left the city with refugees and letters, and of these the following were lost: The "Jacquard," which left the station of the Orleans railway on the night of November 28, 1870, and was sighted near Plymouth, but was never seen again. The other disappearance was that of the "Richard Wallace," which left the Nord station on January 27, 1871; it was sighted at La Rochelle going towards the sea.

One of the most famous of balloon adventures was the high ascent made by James Glaisher and Coxwell on September 5, 1862, from Wolverhampton. The story of Glaisher's many

adventures are given in that delightful volume, *Travels in the Air*, from which I take this one incident. After describing the steady climb upwards to 29,000 feet, Glaisher continues:—

"Shortly afterwards I laid my arm upon the table, possessed of its full vigour, and on being desirous of using it, I found it powerless; it must have lost its power momentarily. I tried to move the other arm, and found it powerless also. I then tried to shake myself, and succeeded in shaking my body. I seemed to have no limbs. I then looked at the barometer; and whilst doing so my head fell on my left shoulder. I struggled and shook my body again, but could not move my arms. I got my head upright, but for an instant only, when it fell on my right shoulder, and then I fell backwards, my back resting against the side of the car, and my head on its edge; in this position my eyes were directed towards Mr. Coxwell in the ring. When I shook my body I seemed to have full power over the muscles of the back, and considerable power over those of the neck, but none over either my arms or my legs; in fact, I seemed to have none. As in the case of the arms, all muscular power was lost in an instant from my back and neck. I dimly saw Mr. Coxwell in the ring, and endeavoured to speak, but could not; when in an instant intense black darkness came, the optic nerve finally lost power suddenly. I was still conscious, with as active a brain as at the present moment while writing this. I thought I had been seized with asphyxia, and that I should experience no more, as death would come unless we speedily descended. Other thoughts were actively entering my mind, when I suddenly became unconscious as in going to sleep. I cannot tell anything of the sense of hearing; the perfect stillness and silence of the regions six miles from the earth (and at this time we were between six and seven miles high) is such that no sound reaches the ear."

While Glaisher was unconscious, Coxwell's hands were powerless. The latter, in order to prevent ascending to still higher regions, pulled the valve-cord with his teeth. Glaisher con-

tinues: "My last observation was made at a height of 29,000 feet; at this time (one hour, fifty-four minutes) we were ascending at the rate of 1000 feet per minute; and when I resumed observations we were descending at the rate of 2000 feet per minute. These two positions must be connected, taking into account the interval of time between, viz. thirteen minutes, and on these considerations the balloon must have attained the altitude of 36,000 or 37,000 feet. Again, a very delicate minimum thermometer read −12°, and this would give a height of 37,000 feet. Mr. Coxwell, on coming from the ring, noticed that the centre of the aneroid barometer, its blue hand, and a rope attached to the car were all in the same straight line, and this gave a reading of seven inches, and leads to the same result. Therefore these independent means all lead to about the same elevation, viz. fully seven miles."

Probably Glaisher was in error in assuming that the balloon continued to ascend at the same rate after he lost consciousness. It should be remembered, also, that his instruments were not of a high order according to modern standards. For many years this was accepted as the highest ascent ever made by a manned balloon, but it is probable that the German balloon "Preussen," in attaining, on July 31, 1901, an altitude of 35,100 feet, beat Glaisher's record. The temperature then experienced was 38° below zero (Fahr.). Both of its passengers were in a fainting condition for three-quarters of an hour.

Another perilous ascent into the upper atmosphere, where there is not enough oxygen in the air to support life, was that of the balloon "Zenith" on April 15, 1875, from Paris, the aeronauts being Tissandier, Crocé-Spinelli, and Sivel. On this voyage, with great determination and in spite of acute suffering, ballast was thrown away until a height of 28,000 feet was attained. Tissandier alone survived this terrible experience, and we will quote here from the end of his narrative:—

"To relate what happened afterwards is quite impossible. I felt a frightful wind. We were still 9700 feet high. There

remained in the car two bags of ballast, which I threw out (the balloon was descending with frightful rapidity and this was done to break the shock of landing). I looked for my knife to cut the small rope which held the anchor, but could not find it. I was like a madman, and continued to call 'Sivel! Sivel!' By good fortune I was able to put my hand upon my knife and detach the anchor at the right moment. The shock on coming to the ground was dreadful. The balloon seemed as if it were being flattened. I thought it was going to remain where it had fallen, but the wind was high and it was dragged across fields, the anchor not catching. The bodies of my unfortunate friends were shaken about in the car, and I thought every moment they would be jerked out. At length, however, I seized the valve-line and the gas soon escaped from the balloon, which lodged against a tree. It was then four o'clock. On stepping out I was seized with a feverish attack and sank down, and thought for a moment I was going to join my friends in the next world."

On this voyage the balloonists were equipped with bottles of oxygen, but probably the appliance was a very imperfect one. Nowadays it is possible to take compressed oxygen in tubes fitted with a mouthpiece which enables suitable quantities to be inhaled. It is advisable to take a little oxygen when at a height of 20,000 to 22,000 feet, and to repeat the doses frequently in order to prevent faintness.

The first long balloon venture to foreign countries, although in the light of later achievements an unimportant journey, appealed to aeronauts of the time as a very dashing enterprise, which indeed it was. The famous voyage of the great Nassau balloon is one of the landmarks in ballooning history. The voyage was made by Mason and Green, the balloon being under the guidance of the latter. The expedition was organised by Robert Hollond, himself an aeronaut. The proprietors of Vauxhall Gardens, Gye and Hughes, had a large balloon in constant use in the gardens, which had been constructed for them by Green. It was the "last word" in ballooning up to

that time. It was shaped like a pear, 60 feet high, 50 feet across—"a form and proportion," says Mason, "admitted to be most consistent with elegance of appearance, and most adapted to the wants and circumstances of aerostation." Modern ordinary balloons, by the way, are almost without exception spherical. When fully distended, the Nassau balloon held 85,000 cubic feet of gas, and was able to raise 4000 lbs., including its own weight and that of its accessories.

At half-past one o'clock on November 7, 1836, all being in readiness, the great balloon rose, and, sailing before a north-westerly wind, made for the Medway at Rochester. When over Canterbury, the aeronauts sent down a letter in a parachute for the mayor. The same thing was done at Dover, and both letters reached their destination.

Over the Channel the travellers tested the merits of the new idea of the guide-rope. To provide against the increase of weight proceeding from the humidity of the night atmosphere, they began lowering the guide-rope, with floating ballast attached, although they were then almost across the Channel.

During the night they found themselves in the centre of a district which blazed with innumerable fires studded in every direction to the full extent of their visible horizon. This was the city of Liége. To its brilliant lights the blackness of night succeeded. "Nothing could exceed its density," says Mason—"not a single object of terrestrial nature could anywhere be distinguished; an unfathomable abyss of darkness visible seemed to encompass us on every side." It was now that the advantage of the guide-rope began to be felt in indicating the changes of level in the ground. The cold during the night was intense—water and oil were completely frozen—but, owing to the absence of all currents of air, the natural result of their situation and one of the particular characteristics of balloon voyaging, the travellers suffered little from this cause.

In the morning the aeronauts prepared to come down. They saw a grassy valley, and after missing it owing to a current

of air near the ground, which threatened to dash them into a wood, they rose, floated over a hill, and after another attempt descended in safety. "Where are we?" they said to the country-folk, who stood about amazed. "In the Duchy of Nassau, two leagues from Weilburg. And where do you come from?" "From London, which we left yesterday." Amazement and incredulity. Finally, the balloon was packed, and carted to Weilburg, where the travellers were fêted and lionised, and the balloon was there and then "christened." It was named the "Great Balloon of Nassau" by Mdlle. Theresa, the daughter of the Baron de Bibra, Grand Maître des Eaux et Forêts.

One of the saddest tragedies connected with aeronautics was the death of two British officers, Lieutenants Martin-Leake and Caulfield, who ascended in the army balloon "Thrasher" from Farnborough in 1907. Four days afterwards the "Thrasher" was picked up empty in the Channel off Weymouth. For a month mystery brooded over the fate of the occupants; then the body of Lieutenant Caulfield was seen in the sea off Chesil Beach. Some days later that of his brother officer was found near Bridport. A coastguard saw the balloon touch the sea near Abbotsbury, but he was positive that the aeronauts were not pitched out. The balloon bounded off, and went out to sea. A curious conjecture as to the circumstances in which these officers were killed was to the effect that finding a descent in the sea inevitable, although it would be close to the shore, they cast lots to decide which of the two should leave the balloon, enabling his companion to remain safely aloft for some hours.

The present writer took part in two adventurous balloon voyages in which the descents provided rather exciting incidents. On October 12, 1907, an attempt was made to break the world's distance record of 1193 miles held by the Count de La Vaulx. The balloon, commanded by its maker, A. E. Gaudron, ascended from the grounds of the Crystal Palace and crossed the North Sea from Yarmouth to the coast of Denmark, a sea distance of 360 miles, the greatest oversea balloon voyage

ever made. The journey terminated at the shore of Lake Wener in Sweden, the total distance being 702 miles, the longest voyage up to that time made from England. The descent had to be made very quickly in a high wind, for the alternative was to be driven over what we believed to be the sea. We had lost our way above the clouds, and on coming down through them and sighting the water, and seeing that it was breaking in foam on the shore and that it extended to the horizon (it is the largest lake in Europe), there was evidently no time to be lost. We came down in a pine forest with a terrific crashing and splintering, dragging three small trees out by the roots. All three of us had hung outside the basket by the hands in order that at a given moment we should jump clear and avoid the danger of one of us being left in the basket. We had no desire to repeat the unfortunate experience of Powell.

Our descent from an altitude of 8000 feet was made at a very great speed, the wind whistling through the ropes with a shrill scream. It seemed as if we were not more than half a minute in falling from that height. By the way, Glaisher and Coxwell once descended 4½ miles in 15 minutes. There is, of course, a limit to the speed attainable in falling on account of the resistance of the air to the huge balloon.

The same balloon ascended from the Crystal Palace on November 18, 1908, and, crossing the sea to the Belgian coast at Ostend, went across the north of Germany, and was finally driven down by snow, after a journey of 31½ hours, at Mateki Derevni, in Novo Alexandrovsk, Russia, a total distance, as the crow flies, of 1117 miles. We came down late at night during a fierce storm of wind and snow, and, on touching ground, in spite of the fact that we pulled the ripping-panel open, we dragged over the frozen snow, through bushes and over a hill for a distance of half a mile, coming to a stop on a frozen lake with the basket turned completely over and all of us huddled up and shaken out of our wits inside. We escaped with

nothing worse than cuts and bruises, and also were fortunate enough to find shelter from the snow and bitter wind in a moujik's cottage. On this occasion Gaudron had for his passengers Captain E. M. Maitland and myself.

The craze for doing something out of the ordinary demanded that some one should be married in mid-air, and the two first people to achieve notoriety in this manner were Roger Burnham and Eleanor Waring, young Americans. They could not find a clergyman willing to perform the ceremony in the balloon, so they decided to do the next best thing, and that was to have a honeymoon in the air. After being married on June 19, 1909, they ascended in a balloon called the "Heart of the Berkshires," which was provisioned for two days' journey. This novel honeymoon only lasted 3½ hours however, the balloon descending at Holbrook, Mass., near Boston Harbour, after a trip of 175 miles. The landing was made in an orchard, and the balloon came down, we are told, "without even a jar"—a happy augury for future domestic peace.

Very terrible must have been the experiences of the passengers of the balloon "Pommern" in an ascent from Stettin on April 3, 1910. The balloon fell into the Baltic, and of the four aeronauts Dr. Delbrueck, a member of the German Reichstag, and Benduhn were killed, while Semmelhack had a foot broken. The following account appeared in the *Times*, which gave also Semmelhack's personal experiences:—

"The balloon rose at 10.30 A.M. from Zabelsdorf gasworks at Stettin in a gale of wind, and had hardly cleared the ground when it was driven into a network of telegraph wires. It tore free from these, breaking the wires in its escape, but only to be hurled against the roof of a neighbouring factory. Twice it was thrown violently against an apparatus of water pipes on the roof, and rebounded against the factory chimney with such violence that the chimney snapped. The 'Pommern,' getting clear now, rose into the air and disappeared rapidly towards the sea. The car was hanging down on one side, and it was

believed that the occupants had fallen out. Nearly three hours later the 'Pommern' was sighted at Sassnitz, on the island of Ruegen, over eighty miles away, driving over the woods at a height of 1500 feet. Then suddenly it was carried away from the shore, and was seen to fall with great speed into the sea. Only one of the occupants seems to have escaped, a bank clerk named Semmelhack, who believes that his companions, Dr. Delbrueck, an architect named Benduhn, and another named Heim, were drowned. Semmelhack was able to save himself.

"It appears that the balloon was carried away before the ballast had been shipped. The survivor, Herr Semmelhack, gives the following account of the horrible adventure: 'The collision of the 'Pommern' with the factory roof was indescribable, and the consequences were fearful. Dr. Delbrueck, who was in command, was badly injured on the head and had a leg broken. Herr Benduhn had an arm and a leg broken and was badly injured on the head. Herr Heim and I were luckier. He was injured on the head, but less severely. I was flung against the side of the car with such force that I fainted. My right leg was crushed. But the collision with the telegraph wires was an even worse business, for the netting of the balloon was torn so badly that only half of the gas-bag was still held by the network, and every moment the gas-bag threatened to tear itself free altogether, when the car would have dropped like a plummet from a height of 2700 feet, to which the balloon had risen. Our only hope was to reach *terra firma* before this happened. With this object in view Dr. Delbrueck tried to let the gas escape, but the cords were broken, and it was impossible to open the escape-cock in the envelope. There was now nothing to be done but to await our fate. We flew over the Haff, passed Swinemuende, and so out over the Baltic to the north-east of Ruegen. We had decided that our only chance was to let the balloon remain aloft as long as it could in the hope that the leakage of gas would ultimately bring us to earth somewhere in Sweden. But fate decided otherwise.

The balloon entered a stratum of clouds and fell to about 150 feet from the surface. The wind was now carrying us directly towards Ruegen, and we resolved to make use of the aeronaut's *ultima ratio* and pull the ripping-cord. We were being blown quietly and slowly towards Sassnitz. When we were about five hundred yards from the shore, Dr. Delbrueck pulled the ripping-cord. With a fearful impact we dropped into the water. We all contrived to get clear of the car, although two of the party had broken limbs, but we were all so exhausted that one after another sank. With my last strength I managed to swim to the balloon, which was lying on the water, and pull myself up by the network. I lay on the top of the envelope and heard our rescuers approaching, when my senses gave way.'"

A thrilling adventure befell three German aeronauts, Captain Joerdens, Distler, and Metzger, who ascended from Munich on Saturday, December 3, 1910. The balloon was carried out to sea, and, descending into the water, Metzger was washed out and drowned. By an extraordinary piece of good fortune the balloon, although it missed the coast of Scotland, actually encountered one of the Orkney Islands, late on Sunday night. The balloonists thought they were in Sweden until they met some of the inhabitants.

"About 7.30 on Sunday morning," stated Distler, "the balloonist's greatest dread appeared. We heard the roaring of the sea. The wind was blowing strongly from the south-east. We came down to locate our position. So great was our speed that the basket dashed against the sea; we three were immersed, and when we rose clear again we were two."

Relieved of the weight of one passenger, the balloon rose out of danger, and all Sunday the balloonists drifted they knew not whither, except that the German Ocean was beneath them. A dense fog hung over the sea to a height of about 100 yards.

Twice during the darkness the balloonists descended, but each time struck the waves. At last everything, even the

anchor, had to be cast overboard, and the emergency rope was pulled to release the remainder of the gas as soon as the balloonists knew they were over land. But so great was the impetus that wire fences and dykes were torn down as the balloon whirled along, while Distler and Captain Joerdens lay crouched in the bottom of the basket expecting each minute to be their last. When they stopped they were a mile inland.

The reader may like to have before him the following list of long balloon voyages:—

1836. London to Germany: 500 miles in 18 hours (Green, Mason, and Hollond).

1870. Paris to Norway: about 1000 miles. One of the balloons that escaped from Paris during the siege.

1897. July.—Distance unknown. Andrée's disastrous attempt to reach the Pole.

1897. Leipsic to Wilna: 1032 miles in 24½ hours. This is not an authentic record; the distance is not "as the crow flies." Godard was the captain of the balloon.

1900. September.—Vincennes to Mamlity: 753 miles (Jacques Faure).

1900. September.—Vincennes to Poland: 706 miles (Count de La Vaulx).

1900. September.—Vincennes to Dantzic: 757 miles (Jacques Balsan).

1900. October.—Vincennes, France, to Korosticheff, Russia: 1193 miles in 35¾ hours (Count de La Vaulx). The world's record.

1900. October.—Vincennes to Rodom, Russia: 843 miles in 27 hours 25 minutes (Balsan).

1906. November.—London to Nevy, Département du Jura: 402½ miles (Leslie Bucknall and Percival Spencer).

1907. April.—Bitterfeld, near Leipsic, to Enderby, Leicestershire: 600 miles in 19 hours (Dr. Kurt Wegener and A. Koch).

1907. October.—London to Brackan, Sweden: 702 miles in 19 hours (A. E. Gaudron, J. L. Tannar, and C. C. Turner). The world's oversea record.

1908. November.—London to Mateki Derevni, Russia, 1117 miles

in 31½ hours (A. E. Gaudron, Captain E. M. Maitland, C. C. Turner). The longest voyage from England.

1910. October.—St. Louis to near Quebec: 1171 miles (Post and Hawley). American record.

The total distance covered by the "America" dirigible balloon in Wellman's attempt to cross the Atlantic in 1910 is not known.

CHAPTER VII

LILIENTHAL AND PILCHER

PARTICULAR honour belongs to those who believed in the possibility of mechanical flight when all the world was against them; not the visionaries who believed in it because they hoped for it merely, but those who by sheer force of intellect perceived the means by which it would be accomplished and directed their experiments along the right path. The names of Lilienthal and Pilcher, one a German, the other an Englishman, are always associated in the minds of students of aeronautics, although they conducted most of their work independently of each other and only had this in common, that both sacrificed their lives in their experiments and both died in the last decade of the nineteenth century. They did not die, however, until they had contributed a very solid mass towards the science of dynamic flight, the work of Lilienthal being especially important.

The name of Otto Lilienthal is now among the most honoured, but curiously his own countrymen were the last to recognise the value of his work. Germany, following the lead of France, but largely because of the work of Zeppelin, strongly favoured the dirigible balloon, and even when the French without neglecting this type of aerial vessel devoted themselves also to heavier-than-air aeronautics Germany did not follow. It was not until the year 1909 that Germany, as a nation, saw anything in flying machines. At the great aeronautical exhibition at Frankfurt am Main in that year, the dirigible balloon and things pertaining to it occupied nearly the whole of the space. The Germans were for the

most part sceptical as to the possibilities of aeroplanes, and frankly regarded the flights that had been made by Frenchmen and Americans as happy flukes. There was at that exhibition, however, a small space given over to a monument to Otto Lilienthal, and when, on the afternoon of July 26th, telegrams were posted up at the news bureau stating that on the previous day Blériot had flown across the English Channel, the imagination of the Germans was stimulated in favour of the flying machine, and the monument to Lilienthal became the object of popular attention. The Germans were quick to claim then that it was one of their race who had been the pioneer of the science.

Otto Lilienthal was born at Anklam on the 24th of May 1848. He and his brother Gustav experimented for many years together, and in 1889 published the results of their labours in the epoch-making book, *Bird Flight as the Basis of the Flying Art*. This work contained the discovery that the curved surface has greater efficiency than the plane in gliding flight. The Lilienthals had studied the flight of birds, and had come to the conclusion that the kind of flight that was possible of imitation mechanically was not by flapping-wing, but was the soaring and gliding methods of certain birds that with wings outstretched and apparently rigid move horizontally and sometimes even in an upward direction. Lilienthal's machine consisted of an arched surface with an area of about 160 square feet, made by stretching thin fabric over a light wooden frame. Its weight was forty pounds. In the centre was an aperture for the experimenter's body, and the contrivance was held in position by his arms. In running down a gentle slope against the wind, sufficient velocity was acquired to lift the machine off the ground. "The feat," wrote Lilienthal, "requires practice. In the beginning the height should be moderate, and the wings not too large, or the wind will soon show that it is not to be trifled with." His first jumps were from a spring-board about four feet

in height, and he slowly increased the height of this take-off, eventually gliding from the slope of a hill and not landing until a distance of 250 yards had been accomplished in the air. Commenting on these experiments he wrote: "To those who from a modest beginning and with gradually increased extent and elevation of flight have gained full control of the apparatus it is not in the least dangerous to cross deep and broad ravines. It is a difficult task to convey to one who has never enjoyed aerial flight a clear perception of the exhilarating pleasure of this elastic motion. The elevation above the ground loses its terrors because we have learned by experience what sure dependence may be placed upon the buoyancy of the air."

He was able to deflect his flight to the right or the left by moving his legs, which were hanging freely from the seat, and he depended upon instinct to maintain his equilibrium. To facilitate his experiments he made a large conical mound in the neighbourhood of Berlin of a height of 50 feet, so that no matter in what direction the wind was blowing he could face it. In one of his machines the extremities of the wings were made of a series of feather-like sails, and these were connected to a small motor near the operator's body and set in motion by the pressure of a knob. This motor was, however, not at all satisfactory on account of the weight. In the year 1896 Lilienthal's experiments had attracted the attention of scientific men everywhere, and in England, France, and America there were a few people who believed in him. His gliding experiments became more and more daring, and he sought to go up in high winds and to be carried along with them. Often he only saved himself by the exercise of quick, dexterous movements, and there is no doubt that he began to develop wonderful skill and knowledge of aerial conditions. He substituted for the one large framework two smaller ones placed one over the other, in reality a biplane, and he found that using this with a wind velocity

of 18 feet per second he was carried in a nearly horizontal direction against the wind without having to take a run to get off the ground. Sometimes he found himself in the air at a standstill at a higher altitude that he had been at the starting point. "At these times," he wrote, "I feel very certain that if I leaned a little to one side and so described a circle, and further partook of the motion of the lifting air around me, I should sustain my position. The wind itself tends to direct this motion; but then it must be remembered that my chief object in the air is to overcome this tendency of turning to the left or the right, because I know that behind or under me lies the hill from which I started, and with which I would come in rough contact if I allowed myself to attempt this circular sailing. I have, however, made up my mind by means of either a stronger wind or by flapping the wings to get higher up and further away from the hill, so that sailing round in circles I can follow the strong uplifting currents and have sufficient air-space around and under me to complete with safety a circle, and, lastly, to come up against the wind to land."

Unfortunately the predictions of the sceptics were verified. On August 11, 1896, while experimenting at Gross-Lichtenfelde, near Berlin, and having flown for a distance of about twenty yards, a gust of wind suddenly caught and carried him upward; he lost control of the machine and fell to the ground, breaking his spine, and died soon afterwards. His brother Gustav, who helped him throughout in his investigations but does not seem to have done much gliding, was still contributing to aeronautical literature in 1910, in which year he had a deeply interesting article in the *Times* on the subject of "Flying without a Motor."

So valuable were Otto Lilienthal's works that it will be useful to give here his own summarised conclusions. He wrote:—

"Artificial flight may be defined as that form of aviation in which a man flies at will in any direction by means of an apparatus

attached to his body, the use of which requires personal skill. Artificial flight by a single individual is the proper beginning for all species of artificial flight, as the necessary conditions can most easily be fulfilled when man flies individually.

"The increasing size of the apparatus makes the construction more difficult in securing lightness in the machine; therefore the building of small apparatus is to be recommended.

"The difficulty of rising into the air increases rapidly with the size of the apparatus. The uplifting of a single person, therefore, is more easily attained than that of a large flying machine loaded with several persons.

"The destructive power of the wind increases with the size of the apparatus. A machine intended to serve for the flight of but a single person is most easily governed in the air.

"The employment of small patterns of flying machines does not permit of any extended observation, because stable flight cannot be maintained for any length of time automatically. Therefore, experiments in actual flight will only be instructive when a man participates in the flight and maintains stable equilibrium at will.

"Experiments in gliding by a single individual following closely the model of bird gliding is the only method which permits us beginning with a very simple apparatus and in a very incomplete form of flight to gradually develop our proficiency in the art of flying.

"Gradual development of flight should begin with the simplest apparatus and movements, and without the complication of dynamic means.

"The sailing flight of birds is the only form of flight which is carried on for some length of time without the expenditure of power.

"With simple wing surfaces similar to those of the bird, man also can carry out limited flights without expending work by gliding through the air from elevated points in paths more or less descending.

"The peculiarities of wind effects can best be learned by such exercises.

"The contrivances which are necessary to counteract the wind effects can only be understood by actual practice in the wind.

"The supporting powers of the air and of the wind depend on

the shape of the surfaces used, and the best forms can only be evolved by free flight through the air.

"The maintenance of equilibrium in forward flight is a matter of practice, and can only be learned by repeated personal experiment.

"Experience alone can teach us the best forms of construction for sailing apparatus in order that they may be of sufficient strength, very light, and most easily managed.

"By practice and experience a man can (if the wind be of the right strength) imitate the complete sailing flight of birds by availing himself of the slight upward trend of some winds, by performing circling sweeps, and by allowing the air to carry him.

"The efficiency of sailing flight upon fixed wings may be increased by flapping the wings or portions of the wings by means of a motor.

"With a proper apparatus, which may be simultaneously used for sailing and rowing flight, a man may obtain all the advantage of bird-flight for a certain duration of flight, and may extend his journey in any direction with the least expenditure of power devisable.

"Actual practice in individual flight presents the best prospects for developing our capacity until it leads to perfected free flight."

Finally, from Lilienthal's directions for practical flight I quote the following (the apparatus will be seen in Plate, p. 88):—

"You hold the apparatus inclined towards the front, take a run against a gentle breeze, and, keeping the apparatus horizontal, make a short leap into the air. In landing, the apparatus is to be lifted towards the front to check the velocity. When the operator feels able the sailing may be gradually extended. If one side of the apparatus is lifted by a gusty wind the centre of gravity must be moved to that side in order to restore equilibrium. The longest flights are obtained when the front edge of the wings lies a very little lower than the rear edge. In a calm the velocity of sailing should be about twenty-two miles per hour, and the course will be from six to eight degrees downwards."

Percy Sinclair Pilcher, a young English marine engineer, in

PILCHER'S GLIDER, "THE GULL"

LILIENTHAL'S BIPLANE GLIDER SOARING

PILCHER'S GLIDER, "THE HAWK"

On this machine the Great Pioneer was killed on October 2nd, 1899.
(Photos lent by the Aeronautical Society.)

1896, his age then being thirty, succeeded with a glider in making several good flights at Eynsford. Pilcher, after six years' service in the navy and going through a course at Elder's shipbuilding yard near Glasgow, then being appointed assistant lecturer in naval architecture and marine engineering at Glasgow University, joined Hiram Maxim, with whose experiments he was closely associated. He then became a partner in a firm of engineers. In 1897 he joined the Aeronautical Society, and was elected to the council in November of the same year.

Pilcher built his first glider early in 1895 in the intervals allowed by his duties at the university. He had seen photographs of Lilienthal's glider and had read the meagre newspaper reports. But his first glider, which he called the "Bat," was his own original conception. The "Bat" was completed before June 1895, when Pilcher visited Berlin, met Lilienthal, and had several glides in the German experimenter's biplane glider.

The wings of the "Bat" sloped upwards to right and left from the centre, *i.e.* a dihedral angle, and it was without a horizontal tail, but had a small fixed vertical surface in the rear. The area of the machine was 150 square feet. Explaining in a paper before the Aeronautical Society the reason for adopting the dihedral angle, Pilcher said:—

"I did this because I believed that it would facilitate transverse balance, on the principle that a piece of paper bent into a V shape will always come down edge first; and a cone will, if dropped, always come down on its point. If stability is got by having the weight very low, as in a parachute, there will be a big oscillation. It must also be remembered that a man soaring, if he meets with an accident, gets a comparatively very much worse fall than a smaller object. An insect can get knocked down by the wind, and remain uninjured.

"The upturned wings were all very well if there was no wind, or if the wind was steady; but if the wind shifted slightly sideways, and came on to one side of the machine, it

would tend to raise the windward wing and depress the lee one, and capsize me sideways, which always meant a breakage in the machine.

"To obviate this I built a second machine quite flat transversely, with the whole surface considerably raised so as to keep the wing tips a good distance off the ground (Plate, p. 88). This machine was, unfortunately, very heavy, and the wing surface being placed considerably above me, I had very little control over it. A sudden puff of wind would carry the machine backwards, leaving me, because of my weight, as it were, behind; and it was only by slipping out of the machine when it was above my head that I several times avoided going head over heels backwards with it."

Pilcher made a machine called the "Gull" and one called the "Hawk." He also constructed an oil-engine of four horse-power, and he attached light wheels and spring shock-absorbers under the front of his last machine for convenience in moving about and landing. He never made an ascent with the motor-driven machine.

In Pilcher's first machines the operator, as the picture shows, was in a low position with respect to the planes, a fact which, according to his own account, made it very difficult to handle. His fourth machine was an exceedingly well-built glider. In spite of the difficulty of working bamboo, Pilcher built the machine up almost entirely of this cane. The tail was formed by a triangular horizontal surface to which was joined a triangular vertical surface. It could only be forced upwards and not downwards. In this machine, too, the operator occupied a somewhat higher position than in its predecessors. This machine was 23 feet 4 inches across from left to right. It had a total length of 18½ feet. Its sustaining surface was 180 square feet. Its net weight was 50 lbs. Balancing was effected by the operator moving his body to and fro to correct any tilting of the wings, and Pilcher acquired great skill in handling this machine.

The "Hawk," carrying a total weight of 190 lbs., glided at a speed of about twenty-two miles per hour, and Pilcher calculated that an engine of about three horse-power would suffice to maintain flight once the machine was in the air. The four horse-power engine which he built weighed 40 lbs. He intended to put the engine in front, and it was to drive, by means of an overhead shaft, a propeller at the rear of the wings.

He was unsuccessful in his efforts to secure a suitable engine, and in order to be able to experiment even when the wind was not favourable he had his glider towed by a line passing over a pulley. This pulley was on the top of a hill; Pilcher took up his position on the crest of an adjoining hill, and succeeded in making several long glides across the valley, a distance of about 250 yards. The "rope" used was a thin fishing-line "which one could break with one's hands," and the pull on it, during flight, did not exceed 30 lbs.

On May 26, 1899, Pilcher attended at the Aeronautical Society to hear a lecture by Lawrence Hargrave on "Kites." He led the subsequent discussion, and afterwards took two of the Hargrave kites away and made experiments with them. It is supposed that their principle was to some extent incorporated in a new machine of which, unfortunately, only a few fragments have been preserved. This was a triplane. The inventor was killed before he had an opportunity to try this machine.

While on a visit to Lord Braye at Market Harborough, Pilcher promised to give a display of gliding, and on Saturday, September 30, 1899, the new machine and the "Hawk" were brought out into a field. Unfortunately, it had been raining heavily and the gliders were soaked through. The "Hawk" was intended to rise from the level field towed by a line passing over a pulley drawn by two horses. The machine rose easily, but the line snapped and the glider descended gently to the ground. Pilcher started again, and was soaring at a height of about 30 feet when one of the wires of the tail broke and the

machine fell headlong. Pilcher was picked up unconscious, and, after lingering on through Sunday, he died early on Monday.

He and Lilienthal were the first real flying men, although possibly Le Bris ought to be given a place with them. Lilienthal was the more scientific, and his work is the more lasting, but Pilcher made important contributions to the science. Thus, in addition to those already mentioned, Pilcher insisted on the great advantage possessed by the small machine over the large one for constructional reasons and ease in controlling, and also he pointed out the evil effects of having the weight suspended too far below the planes.

CHAPTER VIII

TRIUMPH OVER RIDICULE

MANY of the pioneers in aerial navigation who worked in obscurity have, after death, been recognised and honoured. But in three cases at least the reward, after long delay, has come in the worker's lifetime. Properly to understand the discouragement that attended the labours of the earlier investigators, or for that matter of those of the last century, we must read what the orthodox scientific man had to say about the whole subject of aeronautics.

"Of what use is a new-born babe?" asked Benjamin Franklin on seeing one of the earliest attempts of a Montgolfier hot-air balloon. This somewhat cryptic remark at any rate seems to suggest that the babe might grow and prove itself useful for something. It certainly had not the crushing effect of the remark by Lord Kelvin, who, a hundred years later, on being asked by Major Baden-Powell to join the Aeronautical Society of Great Britain, emphatically declared that he had not the smallest molecule of faith in aerial navigation other than ballooning, or of expectation of good results of any of the trials he had heard of. "So," he adds, "you can understand that I would not care to be a member of the Aeronautical Society." This was in 1896. In 1902 Lord Kelvin said, "The day is a long way off when we shall see human beings soaring around like birds"; and again, in 1908, he said, "For many years, in fact ever since I became acquainted with the work of Penaud and Wenham, I have leaned to the opinion that flight was possible as a feat. This question is now settled, and the tendency may be to jump too quickly to the conclu-

sion that what can be done as a feat will soon be possible for the purposes of daily life." The last statement shows that Lord Kelvin had slightly changed his attitude since 1896, but it scarcely recognises the possibilities as we know them of aviation. If that was the attitude of orthodox science at the time the Wright brothers were making their first flights in Europe, what must have been the enlightened opinion of the ages before the light motor was made?

We have to recollect that until the closing years of the nineteenth century the lightest of engines were enormously heavy as compared with the modern petrol motor. Literally, it was not the practical engineer and scientist, but the visionary—the unpractical dreamer—who imagined that some day some new principle in chemistry or mechanics might give us a light motor. In 1880 Edison, who besides being practical was imaginative, and had the type of mind that always admits, as to any particular problem, that one day humanity might solve it, began to investigate the subject of aerial navigation. His experiments with aerial propellers driven by an electric motor discouraged him to such an extent that he declared: "The thing will never be done until an engine of fifty horse-power can be devised to weigh about 40 lbs."

The whole world was waiting for the invention of the light petrol motor. Those who cannot remember, whose memory cannot go back to the days before motor-cars, can scarcely realise how the world has changed. The problem of flight had really been solved long before. Maxim had said, "Give us the light motor and we will fly." There is not the slightest doubt that the aeroplane would have become practicable in the beginning of the nineteenth century had the light petrol motor come into existence.

It is, therefore, the more remarkable that long before motor-cars began to throng the roads of France, the internal combustion motor was actually evolved and yet was not recognised by the world. Fernand Forest in 1888 produced an

explosion motor at his workshop at Suresnes. He was the unrecognised pioneer of the motor-car, and it was not until the horseless carriage and the flying machine had become common that his country recognised Forest and, tardily, in 1910 bestowed on him the Cross of the Legion of Honour in acknowledgement of his invention of explosion motors and electric-spark ignition.

In his early days lack of funds and the vagaries of the French patent-law combined with the circumstance that the world was not ready for the petrol motor to deprive him of the fruits of his genius. His inventions were swallowed up and perfected by others at the beginning of this century. Professor Painlevé placed Forest on a level with Watt. At the Conservatoire of Arts and Crafts three cases filled with his models may be seen. When the long-delayed decoration was bestowed upon him his six sons were still employed as mechanics at Suresnes, where he himself was still working out new inventions. He never complained with any bitterness during the time that he was neglected, and in that respect he was a contrast to Clement Ader, the first man to fly with a motor-driven flying machine, who in his disappointment at official neglect and breach of obligations burned all his drawings and writings, and was only prevented from destroying his machine by a friend who appealed to him on the ground of patriotism.

Ader was born in 1841. He became an engineer and studied electricity, and, as long ago as 1860, made himself a bicycle with rubber tyres. In his youth he became possessed of the idea that human flight was possible. He read Mouillard's *Studies of Large Birds*, and following up these ideas he obtained eagles and bats, and carefully observed their flights in his workshop. But to pursue the matter further he went to Algeria. He was, however, unable to find any large vultures near the coast, so he disguised himself as an Arab, and with two Arab guides travelled into the interior. It was his method

then to entice the birds with pieces of meat while he took "cover" and watched their movements—a modern Sindbad. From these studies he concluded that the vultures, whose wing-span is some ten feet, do not flap their wings when rising in the air. They beat them two or three times in getting off the ground, and then spread them out facing the wind upon which they rise. By adjusting their wings to the various conditions of the wind they ascend in great curves and circles.

Ader spent more than £25,000—practically all his private means—in aerial experiments before he built the large artificial bird with which he actually flew. He kept the machine hidden, but many people knew that he was making experiments in the private park of Pereire, the banker.

In the summer of 1891 an artist caught a glimpse of the machine through the trees of the park, and soon after it leaked out that Ader's bird had risen to a height of 60 feet and flown for 600 feet.

At this critical moment, when triumph seemed assured, de Freycinet, the French Minister of War, in whose cognisance the experiments were being made, and to whom General Mensier, who witnessed the experiments, made a favourable report, practically abandoned Ader. Yet he realised the importance of the invention, for he placed upon the inventor the seal of secrecy, making of the whole business a State matter to divulge which would have amounted to high treason. This tied Ader's hands completely, and he lived on from month to month, hoping for the removal of the ban. In 1897 General Bilot, Minister of War, refused to prolong the arrangement entered into by Freycinet, and the inventor was free to obtain private patronage.

But it was now too late. The capitalists to whom he appealed for assistance were convinced that his desertion by the Government was proof that the machine was useless. In a moment of very natural disgust he burnt all the papers relating to the machine, and was only prevented from smashing

that up by the earnest appeal of a friend. Eventually it found its way into the Arts and Handicrafts Museum in Paris, where it remained until the autumn of 1908, when it was placed in the first Aeronautical Salon, side by side with the aeroplanes of Wilbur Wright, Delagrange, and Blériot, as convincing proof that to France belonged the honour of making the first flying machine.

Ader's first machine was the "Eole," the speed of which on the ground was 36 miles per hour. It was this great speed which first attracted the attention of de Freycinet. The "Eole" machine measured 54 feet across, and was driven by a steam-engine actuating a propeller. The "Avion," which succeeded it, had two propellers, and its wings were flexible. There is no doubt that Ader anticipated the Wright Brothers' device for obtaining lateral stability by having wings that could be bent up or down alternately at the will of the operator. It was on this machine that, on the 14th of October 1897, Ader made his flight of nearly 300 yards, as to which he says that leaving the ground, although that was, of course, his sole object, took him so much by surprise that he nearly lost his senses. The machine came to grief. As a fact, considerable wind was blowing at the time, and he ought not to have made the experiment, but there were high military officers present, and no doubt the importance of the occasion sat heavily on Ader's nerves. He ought to have declined to fly under the circumstances, but he had not the courage to do so.

In the following year, 1894, Maxim made a flying machine which actually left the ground carrying its engine, boiler, fuel, and water. The machine did not achieve flight in the sense in which we understand it, for in order to avoid disaster the inventor had contrived check rails to prevent it ascending more than a few inches. It strained at these rails and broke them. Maxim's machine weighed 8000 lbs., and its engine developed 360 h.p. Scarcely anybody in England attached the slightest importance to Maxim's work, and yet he demonstrated that a

flying machine carrying its own engine could be made powerful and light enough to fly, that it could attain high speed, and that a screw-propeller was capable of acting on the air just as it does in the water. Maxim himself said, "It is now only a matter of time. Give us the light motor and we will fly." Nobody paid any attention to him or to anybody else at that date who expressed any faith in the possibility of mechanical flight. Again, it was not until the Wrights, and Farman, and Delagrange, and Santos-Dumont, in 1908, showed what could be done with the petrol motor that the world remembered Maxim. Then he was besieged by newspaper interviewers for his opinions on flying, and he was able to say not only that he had predicted it, but that fourteen years previously he had demonstrated it.

CHAPTER IX

TO THE NORTH POLE

VERY soon after travel in the air had been realised, the idea of geographical exploration by means of balloons was seriously entertained. Delaville Dedreux suggested, as long ago as 1863, a journey to the North Pole, and others who pointed out the possibility were C. G. Spencer and Major Baden-Powell. The latter, addressing the British Association at Bristol, propounded the following enterprise:—

"I should suggest several balloons, one of about 60,000 cubic feet, and, say, six smaller ones of about 7000 cubic feet; then, if one gets torn or damaged, the others might remain intact. After a time, when gas is lost, one of the smaller ones could be emptied into the others, and the exhausted envelope discharged as ballast; the smaller balloons would be easier to transport by porters than one big one, and they could be more easily secured on the earth during contrary winds. Over the main balloon a light awning might be rigged to neutralise, as far as possible, the changes of temperature. A lightning-conductor to the top of the balloon might be desirable. A large sail would be arranged, and a bifurcated guide-rope attached to the end of a horizontal pole would form an efficient means of steering. The car would be boat-shaped and waterproof, so that it could be used for a return journey down a river. Water tanks would be fitted."

The first attempt to reach the North Pole by balloon was made by Andrée, whose plan of campaign was characterised by a daring that won the world's admiration but caused many experienced aeronauts to feel grave doubts as to the result.

Salomon Auguste Andrée was born at Grenna, in Smoiland, Sweden, on October 18, 1854. His father was a chemist. Young Andrée studied for the profession of engineering, afterwards working as a simple mechanic for a time in order to gain practical knowledge. At the age of twenty-six he became Assistant Professor of Pure and Applied Physical Science at a technical school. In 1882 he took part in a meteorological expedition to Spitzbergen. Afterwards he was made chief engineer at the Patent Office at Stockholm, and in 1892 he received from the Swedish Academy of Science and the "L. J. Hjerta Memorial Foundation" a subvention for the purpose of undertaking scientific aerial navigation. From that time he devoted himself to the subject.

His first balloon ascent was in the summer of 1893, and in October of that year he had a dangerous adventure. The balloon was carried out to sea, and he found himself confronted with the alternative of falling into the water or, in the event of the wind carrying him sufficiently swiftly, to make the coast of Finland before the balloon lost its buoyancy. By throwing away every movable article he kept aloft until the land was sighted, but then a change of wind, just as night was setting in, drove him along parallel with the coast. Standing on the edge of the basket with the last item of ballast in his hand he watched for an opportunity to descend. He actually passed over a small island, but failed to effect a landing, and so fell into the sea on the other side. The balloon swept towards another rock, and Andrée, greatly exhausted, managed to jump out on to *terra firma*, but in falling he sprained one of his legs. No one was within call, and the aeronaut was forced to pass the night under somewhat distressing circumstances. In the morning he managed to summon up enough strength to signal with his clothes, and after a time a boatman rescued him. He had numerous other adventures while ballooning.

Early in 1895 he presented to the Academy of Science a project for exploring the region of the North Pole with the aid

[Record Press

CIRCLING THE LEANING TOWER OF PISA

Mario Cobianchi on his Farman biplane in a novel situation.

of a balloon, at a cost of £7177. The start was to be made from Spitzbergen. Sufficient money was raised by national subscriptions, A. Nöble giving £3588 and the King of Sweden £1656.

Andrée then spent much time in interviewing balloon-makers and in testing materials. Finally the balloon was made for him in Paris. It had a capacity of about 160,000 cubic feet. It was made with a contrivance by which the trail-rope could be moved to different positions in the car; and it also had a sail, the object of which was to steer the balloon. A sail is, of course, useless unless the speed of the balloon is retarded by a drag running along the ground. This causes a certain amount of wind-pressure which can be utilised for steering. It is instructive to examine the elaborate equipment of Andrée's balloon. Lachambre and Machuron in their book on *Andrée and his Balloon* gave it as follows:—

"The three guide-ropes, weighing 1984 lbs., were stretched from the shore to the hoop, and also eight other cables, each 76 yards long and weighing together 881 lbs. These latter, together with the guide-ropes, served to prevent the balloon from coming too close to the earth, giving the effect of throwing out ballast to the extent of 881 lbs. more than the weight of the guide-ropes before the car could touch the ground. Under these conditions the balloon would always keep its centre of gravity, even when exposed to a storm. The above-mentioned eight ropes served another important purpose—they could be used to lengthen the guide-ropes on in case of necessity. Andrée could get rid of the lower part of the guide-ropes by a screw locked by a spring which connected this part with the rest of the hoop, a turn given from the top of the car being sufficient to start the spring and the screw. A second method consisted of a dynamite explosive.

"The car was stored with articles of all kinds—scientific instruments, compasses, sextants, telescopes, photographic appliances and accessories, pharmaceutical preparations, culinary

articles, lamps and electric batteries, arms, ammunition, &c. &c. Every space was utilised or set apart for some particular purpose. The provisions for the expedition consisted of preserved foods and wines of all kinds, packed in labelled packets made of strong material, and laid one over another so as to form one long bag; thirty-six similar bags containing 1663 lbs. of food were attached to the top of the hoop by thirty-six suspending ropes. Andrée took enough food for four months only.

"Twelve remaining ropes were hung with sledges, snowshoes, a boat formed of a wooden framework that could be taken to pieces, and covered with a doubled covering of waterproofed material of the same nature as the envelope of the balloon. This very light boat measured six yards in length, and was a marvel of skilful construction. Every one was surprised to see the quantity of things that could be stowed away in the rigging without causing any confusion, and arranged over the platform of the hoop, within reach. On the hoop itself a number of articles were placed—picks, shovels, hatchets, anchors, a little windlass, buoys, &c. All these articles were of bronze or copper, the hatchets having a steel blade set in copper. Andrée also took twelve despatch-buoys, each consisting of a sphere of cork 7¼ inches in diameter coated with a thick coat of paint, partly blue and partly yellow, and protected by a network of copper-wire. At the bottom the buoy was weighted by a cone filled with lead, which gave it the appearance of a top. At the upper end was a copper stopper inscribed with the words 'Andrée's Polar Expedition, 1896,' and a number. This stopper closed a cavity cut in the cork to receive a tube in which would be enclosed documents or messages from the explorers. The buoy was surmounted by a spiral spring of copper supporting a little Swedish flag of thin metal. The buoys were to be thrown out at different points of the voyage of the balloon. A thirteenth, larger than the others, was to be left at that point of the route nearest to the geographical Pole that could be reached by the balloon."

It was estimated that 5510 lbs. of ballast and emergency ballast could be carried. By "emergency ballast" is meant sails and other equipment that could, in case of necessity, be thrown overboard. Andrée hoped that the balloon could keep aloft for fifty days, but if all went well it would in a very few days cross the region of the Pole and land either in Siberia or Alaska.

In the summer of 1896 his preparations for an aerial dash to the North Pole were completed. On June 7th the party embarked at Gothenburg, arriving at Spitzbergen on the 21st. Andrée and his two companions, Nils Strindberg and Dr. Ekholm, finally selected Dane's Island as a suitable place from whence they might start their great voyage. By July 27th all was in readiness, and with the inflated balloon they waited for a favourable wind for the start. But after waiting for three weeks without any change of wind to the right quarter, the captain of the ship that had conveyed them and their equipment to the island said that they must return at once to avoid being frozen in for the winter. They had no choice but to return home, leaving the shed and gas-generating apparatus for another occasion.

On May 28th of the following year they started again for Dane's Island. Frankel and Svedenborg accompanied Andrée and Strindberg, as Dr. Ekholm had retired from the expedition. From May 30th to July 11th they waited, and then, with a wind somewhat west of south, they started on the ill-fated voyage. The departure was described by Machuron as follows :—

"The entire crew of the Svensksund are present, and also the crews of the three Norwegian whaling vessels anchored in Virgo Bay. There is profound silence at this minute; we only hear the whistling of the wind through the woodwork of the shed, and the flapping of the canvas, which hangs over the upper part of the south side.

"Among the cordage of the car are seen the three heroes, standing admirably cool and calm. Andrée is always calm,

cold, and impassible. Not a trace of emotion is visible on his countenance; nothing but an expression of firm resolution and an indomitable will. He is just the man for such an enterprise, and he is well seconded by his two companions.

"At last the decisive moment arrives.

"'One! Two! Cut!' cries Andrée in Swedish.

"The three sailors obeyed the order simultaneously, and in one second the aerial ship, free and unfettered, rises majestically into space, saluted with our heartiest cheers.

"We rush to the doors to get out of the shed. I have the chance of getting out first through a secret opening I have made in the woodwork, so as to be able to rush to my photographic apparatus and have time to take a few snapshots at this stupendous moment.

"Being encumbered with the heavy cordage that it takes with it, the balloon does not rise to a height of 100 metres. It is dragged by the wind. Behind the mountain that is sheltering us stormy winds are raging, and a current of air sweeps down from the summit and attacks the balloon, which for a moment descends rapidly towards the sea. This incident, which we had foreseen before the departure, but the natural cause of which struck few of the spectators at the moment, produces great excitement amongst some of us. The sailors rush to the boats to be ready to lend assistance to the explorers, whom they expect to see engulfed in the waves. Their alarm was of short duration; the descending movement soon becomes slower, and the car just touches the water and ascends again immediately.

"Unfortunately, the lower parts of the guide-ropes, which were made so as to become detached if they should be caught in the ground, have remained on the shore. At the start, the ropes were caught in some rocks on the shore, and the screws for separating the parts worked loose. But Andrée is well provided against this loss, so that this accident is not likely to have serious consequences.

"At the edge of the water, on the beach studded with rocks and large stones, we all stand, breathlessly watching the various phases, rapidly following one upon another, of the commencement of this stirring and unprecedented aerial journey.

"The balloon, which has now righted itself at about 164 feet above the sea, is rapidly speeding away, the guide-ropes glide over the water, making a very perceptible wake, which is visible from its starting-point, like the track made by a ship. The state of affairs seems to us on the shore to be the best that could be hoped for. We exchange last signals of farewell with our friends, hats and handkerchiefs are waved frantically.

"Soon we can no longer distinguish the aeronauts, but we can see that they are arranging their sails, as these latter are displayed in succession on their bamboo mast, then we observe a change of direction. The balloon is now travelling straight to the north. It goes along swiftly, notwithstanding the resistance that must be offered by the dragging-ropes. We estimate its speed at from eighteen to twenty-two miles an hour. If it keeps up this initial speed and the same direction, it will reach the Pole in less than two days.

"The aerial globe seems now no bigger than an egg. On the horizon an obstacle appears in the route; this is the continuation of a chain of mountains about 100 metres high, right in the path of the balloon, which seems very close to the obstacle, and some of the sailors round me, who have never before seen a balloon start on its trip, seem in great terror. They think the balloon will be hopelessly wrecked. I reassure them, telling them that the balloon is still far away from the hills, which will be easily surmounted, without there even being any necessity to throw out ballast.

"The balloon travels on, maintained at the same altitude by the guide-ropes. In the neighbourhood of the hills there is an upward current of air; the balloon will follow this; it would

only risk striking against the obstacle if the movement were downwards, which is not the case. Moreover, the guide-ropes first rest upon the rocks and thus lighten the balloon, which gradually rises. We see it clear the top of the hill, and stand out clearly for a few minutes against the blue sky, and then slowly disappear from our view behind the hill.

"Scattered along the shore, we stand motionless, with hearts full, and anxious eyes, gazing at the silent horizon. For one moment then, between two hills, we perceive a grey speck over the sea, very, very far away, and then it finally disappears.

"The way to the Pole is clear, no more obstacles to encounter; the sea, the ice-field, and the Unknown!

"We look at one another for a moment, stupefied. Instinctively we draw together without saying a word. There is nothing, nothing whatever in the distance to tell us where our friends are; they are now shrouded in mystery.

"Farewell! Farewell! Our most fervent prayers go with you. May God help you! Honour and glory to your names!"

On July 22nd one of Andrée's pigeons was killed by some fishermen near Spitzbergen. It carried the following message:

"The Andrée Polar Expedition to the *Aftonbladet*, Stockholm.

"July 13th, 12.30 P.M., 82° 2′ north latitude, 15° 5′ east longitude. Good journey eastwards, 10° south. All goes well on board. This is the third message sent by pigeon.

"ANDRÉE."

On August 31st a buoy was picked up bearing the message:

"Buoy No. 4. First to be thrown out. 11th July, 10 P.M., Greenwich mean time. All well up till now. We are pursuing our course at an altitude of about 250 metres. Direction at first northerly 10° east; later, northerly 45° east. Four carrier pigeons were despatched at 5.40 P.M. They flew west-

wards. We are now above the ice, which is very cut up in all directions. Weather splendid. In excellent spirits. Andrée, Strindberg, Fraenkel. (Postscript later on.) Above the clouds, 7.45, Greenwich mean time."

The Anthropological and Geological Society at Stockholm later received the following telegram from a ship-owner at Mandal:—

"Captain Hueland, of the steamship Vaagan, who arrived there on Monday morning, reports that when off Kola Fjord, Iceland, in 65° 34′ north lat., 21° 28′ west long., on May 14th, he found a drifting buoy, marked 'No. 7.' Inside the buoy was a capsule, marked 'Andrée's Polar Expedition,' containing a slip of paper, on which was given the following: 'Drifting buoy No. 7. This buoy was thrown out from Andrée's balloon on July 11, 1897, 10.55 P.M., Greenwich mean time, 82° north lat., 25° east long. We are at an altitude of 600 metres. All well. Andrée, Strindberg, Fraenkel.'"

In December 1909 an extraordinary story was published on the authority of a missionary who had devoted many years of his life to work among the Eskimos. The missionary reported to his bishop that in the course of his wanderings in the extreme north of Canada he came across an unknown tribe of Eskimos, who had come from the farthest north. According to what they told him, they had a strange experience at a period which must have been some years ago. They said that they were one day astonished to see a "white house" in the sky coming down towards the earth. In it they found two half-starved white men, but though their vitality was to a certain extent restored by meals of reindeer flesh, they were so weak that they died shortly afterwards. The Eskimos stated that they used the "white house" as a storeroom for the ropes, of which there were a great number attached. They still had with them several ropes, all well-made and remarkably strong.

Many other reports have appeared regarding alleged discoveries of traces of Andrée and his expedition, but on investigation they have proved to be without foundation.

One of these stories suggests that Andrée and his companions were slain by the Eskimos. Another relates to the finding of a lonely grave marked by a wooden cross with the word "Andrée." But Andrée is a very common name; and, indeed, none of these reports was ever verified.

Percival Spencer commenting on the expedition says:—

"The distance from Dane's Island to the Pole is about 750 miles, and to Alaska on the other side about 1500 miles. The course of the balloon, however, was not direct to the Pole, but towards Franz Josef Land (about 600 miles) and to the Siberian coast (another 800 miles). Judging from the description of the wind at the start, and comparing it with my own ballooning experience, I estimate its speed as 40 miles per hour, and it will, therefore, be evident that a distance of 2000 miles would be covered in 50 hours, that is two days and two hours after the start. I regard all theories as to the balloon being capable of remaining in the air for a month as illusory. No free balloon has ever remained aloft for more than 36 hours" (this record was beaten a few years after Spencer wrote), "but with the favourable conditions at the northern regions (where the sun does not set and where the temperature remains equable) a balloon might remain in the air for double the length of time which I consider ample for the purpose of Polar exploration."

The Wellman airship expedition to the North Pole was another tangible enterprise. This was to be attempted in a dirigible balloon, also starting from Dane's Island. Abortive attempts were made in 1907 and 1909. The gas-container of this balloon had a capacity of 258,500 cubic feet. It was 184 feet in length and 52 feet in diameter. The motive power was obtained from a 70 to 80 h.p. Lorraine-Dietrich engine. To

maintain the gas-envelope in a fully inflated condition, a separate 4 h.p. motor was carried to compress air and conduct it to an internal ballonnet placed in the lower part of the main balloon. The car had a strong frame of steel tubing, and a completely enclosed central section which comprised the engine-room and living-room. For maintenance of vertical equilibrium a guide-rope weighing 1800 lbs. was constructed to act equally well upon water and upon ice. The lower end had four steel cylinders about 10 feet apart attached to the steel cable, with wooden runners outside. The cylinders were so arranged that they would float in water.

Wellman abandoned his project after the misfortune of the storm which wrecked his balloon-shed, followed by the breaking of the provision-packed guide-rope, synchronising as these incidents did with the discovery of the North Pole by Peary.

Zeppelin, however, was enamoured of the idea, and believed that his rigid balloons would prove capable of even an Arctic voyage, and investigation has been in progress for some time with this object in view.

With regard to these Polar expeditions one is forced to consider that scarcely sufficient allowance had been made for unknown meteorological conditions. They would inspire more confidence were they to proceed carefully step by step, only making the "dash to the Pole" when provided with a mass of data affording them reasonable hope of success. The cost of these enterprises is formidable, and money, alas! has never been easily obtained for scientific work of any kind.

CHAPTER X

CRITICAL MOMENTS IN THE AIR

EVERY man who first entrusts his life to the supporting power of the invisible air, whether in a balloon, a parachute, or an aeroplane, feels the thrill of adventure and the romance of the unknown tingling in his blood. Especially to the earlier experimenters, and the bold and mistaken enthusiasts who were found in almost every generation ready to experiment with artificial wings, must the spirit of adventure have appealed. Every venture of the kind was critical and hazardous, and each one, considered from this point of view, is full of interest. But the history of the successful navigation of the air by various means teems with remarkable and thrilling incidents, and of these I now propose to narrate a few, selected almost at random, and told, in every case in which I have been able to obtain the material, by the aeronaut himself.

It is difficult to imagine the sensations of the first aeronaut who experienced a balloon-burst in mid-air. One of the most remarkable experiences of this kind was that which befell John Wise, the famous American balloonist, in 1836 in an ascent from Philadelphia. He had set free two parachutes containing animals when a thunderstorm broke over him. He wrote of this: "It seemed to me as though heaven's artillery were celebrating the occasion of the progress of the new-born science, and it inspired me with a determination to try the new experiment of atmospheric resistance as a means of safe descent in the event of the explosion of the balloon at great heights."

The second of his parachutes was nothing more than a balloon in a collapsed state, as it was, indeed, an experiment to

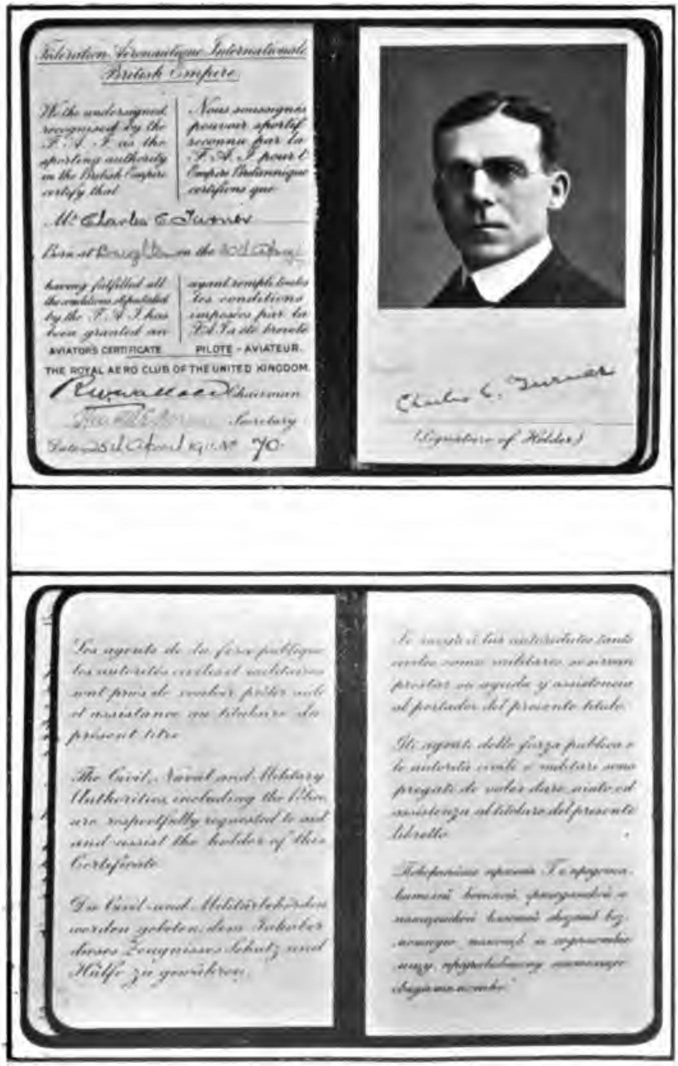
ascertain whether a burst balloon would come to ground slowly. Wise believed that a balloon in a flaccid state would cave in underneath and descend like an open umbrella. In this case, after the release of the two burdens, an altitude of 13,000 feet was attained. The balloon became expanded to its utmost tension on account of the reduced pressure of the outside air at that height, and at every moment Wise expected it to burst. He says: ". . . Became somewhat excited, and as I looked over the side of my car I observed the sparkling coruscations of lightning springing from cloud to cloud a mile beneath me. . . . I took out my watch, noted on my log-book the time—twenty minutes past two—and as I was about returning it to my pocket, thinking at the time whether it were not best to relieve the explosion-rope (*i.e.* open the valve), discharge ballast, and abandon for the present the idea of this experiment, the balloon exploded. Although my confidence in the success of the contrivance never for a moment forsook me, I must admit that it was a moment of awful suspense. The gas rushed from the rupture in the top of the balloon with a tempestuous noise, and in less than ten seconds not a particle of hydrogen remained in it. The descent at first was rapid, and accompanied with a fearful moaning noise caused by the air rushing through the network and the gas escaping from above. In another moment I felt a slight shock. Looking up to see what caused it, I discovered that the balloon was canting over, being nicely doubled in, the lower half into the upper. The weight of the car, however, countervailed the tilted tendency, giving it an oscillating motion which it retained until it reached the earth. The velocities of these zigzag descents were marked by corresponding notes of the wind as it whistled through the rigging of the balloon. . . . The oscillations became more severe, each one causing a sensation in me similar to that which a person experiences when dreaming that he is falling. The wind from the south-west drifted the machine several miles before it fell to the earth. As I neared *terra firma* all the ballast was thrown overboard, but when I struck it was

with a violent concussion. The car struck the earth obliquely and I was thrown about ten feet forward from it."

Since Wise's experiment many balloons have burst in the air, but never have the aeronauts been killed in the fall. Yet these incidents are always described as miraculous escapes. As a matter of fact the parachute-like descent of a burst balloon is almost a mathematical certainty. The worst danger in a balloon descent is when a high wind is blowing and the car is dashed against the ground or against the side of a hill with great violence. There have been bad accidents of this kind. Most balloonists have experienced rough tumbles in descending and more or less exciting incidents during their aerial travels, but the comparative rarity of serious accidents shows that with care it need not be a dangerous pastime.

One of the most remarkable escapes from deadly peril was experienced by A. E. Gaudron, the navigator of the balloon which, with the present author as a passenger, in October 1907 went from London to Brackan in Sweden, the oversea part of the voyage, 360 miles, being a world's record. He was also the captain of our balloon expedition which, in November 1908, travelled from London to Mateki Derevni, near Dvinsk, in Russia, a distance, as the crow flies, of 1117 miles. The adventure which I am about to record had better be told in Gaudron's own words, and he has kindly narrated it for the reader. He was at Trieste in Austria at the time, and was to make a parachute descent. He found some difficulty through not speaking Italian, which is the common language there, and although he had an interpreter a mistake was made which nearly cost him his life. This is how he describes it:—

"The event was arranged to take place from an enclosure near the seashore. The inflation of the balloon was completed in due course, and the parachute attached to the netting by a cord of a strength sufficient to sustain it, but which would break with my weight when I left the sling on which I was seated ready for ascent. The trapeze-bar of the parachute was



The Aviator's Certificate

Granted to the Author by the Royal Aero Club of the United Kingdom.

being held away from the balloon by a man who was to hand it to me at the last moment. This was done to keep the lines of the parachute in good order and prevent them from becoming entangled with the persons who were holding down the balloon.

"I gave an order through the interpreter to 'let up a bit,' but he translated it into 'all let go.' The consequence was that the parachute broke off the netting and fell down to the ground entirely lost to me, while I was carried up without any means of making a speedy descent, sitting on a sling of rope below a balloon which, being without a valve, it was quite impossible to control. Higher and higher I rose, and was very soon over the sea with a strong wind blowing me away from the land. My first thought was that I was lost, but I quickly roused myself to think of what I could do to save myself. I had no valve to let out the gas, and if I stayed on the balloon it would perhaps be two hours before it came down of its own accord through natural exhaustion of gas. If I remained, I should by that time be about seventy miles out in the Adriatic Sea, and it would be dark.

"What way could I find out of this terrible position? There was only one thing I could do, and that would be extremely dangerous. However, nothing could be much worse than having to stay where I was, so I resolved to try it. I thought if I could manage to crawl up the netting and, with my weight bearing on one side, turn the balloon somewhat over, it would allow some of the gas to escape through the open neck and make the balloon descend. I knew I should have to be extremely careful how I went about it, or either of two things might happen—I might let out too much gas and descend with such rapidity as would inflict serious injuries when I reached the water, or the balloon might shoot out of its net and let me fall headlong, to be dashed to death on the sea below.

"I had started with some 2 cwt. of lifting power, and was

by this time a mile and a half away from land at a height of about 4000 feet with only a loop of rope half an inch in diameter for a seat. To remain on the balloon was certain death, so I resolved to take the risks I have mentioned, and left my seat on the rope, and thrusting my legs in amongst the leading-lines commenced climbing up the netting. Of course my weight was always underneath, and as I moved upwards the position of the balloon changed. I soon got the neck at the place usually occupied by the equator of the balloon when the same is in normal position, but it made very little difference. It was now time to exercise great caution in my movements, so I gradually tilted the balloon more and more until the neck was about two-thirds up, when the gas suddenly began to rush out. I brought the neck down a bit so as to keep what gas was left, and the balloon, which had become about half-emptied, started to come down with great rapidity, the rush of the air forming it into a sort of parachute. The speed of my fall increased every moment, and in about four minutes I fell into the water on my back with a tremendous smack. I was then about 3½ miles from the shore. I released my hold of the balloon and looked about me for help. I could see a small steamer coming to my rescue, and knew I was now safe. About ten minutes later I was picked up and taken on board the steam-tug and conveyed to the shore, where a multitude of people were anxiously waiting to receive me."

It is inevitable that in other chapters thrilling adventures in the air should find a place, and an exact classification of subjects in a book of this kind were impossible unless one printed certain parts of it in more than one place. Here, however, may be recorded two or three aeroplane adventures which do not come under other heads in the book; but before proceeding with them, one more incident of a burst balloon may be worth a brief reference. The "Printanier" was a captive balloon used for making ascents at the Porte Maillot entrance

to the Bois de Boulogne, Paris. One afternoon the balloon, containing nine passengers, two of whom were ladies, was struck by a squall when it had returned to within 100 feet of the ground. The cable snapped, and the balloon bounded into the air to a height of over 9000 feet and disappeared through the clouds. One man jumped from the car just before the cable snapped at the moment when the basket was driven down by the wind; the other eight passengers remained in the liberated aerostat. The balloon soon began to descend, the gas rapidly escaping and the envelope sagging upwards and forming a parachute. But to the horror of the spectators the envelope was seen suddenly to tear into ribbons. The pressure of the air had proved too great for its strength. The descent became very swift, and the occupants of the car left it and climbed up the rigging. Luckily the landing took place in a fairly open place, so that after the first rebound there was no danger from buildings. It was remarkable that although their terrifying experience had seriously affected the nerves of the passengers none of them were physically injured.

There is one peril, however, from which no balloonist could hope to escape, and that is fire. It is dangerous to light a match in a balloon, although it does not necessarily follow even if the gas ignited that the balloon would not reach the earth gently. Gas burns quickly, yet it takes time, according to the size of the aperture through which it is pouring. The danger is from an explosion. A certain mixture of gas and air is extremely explosive, and it is precisely this mixture which is found near the neck of the balloon where escaping gas is mingled with the air. Hence the danger from naked lights. Balloonists, however, knowing the danger can provide against it, and it has been a common practice to take fireworks up in the air and set them off by electric spark suspended at some distance below the gas-envelope. The author has been in balloons during this operation; but an American aeronaut once had a very terrible experience in making a similar attempt. Through some one's

carelessness some fireworks in the car of the balloon became ignited and the gas itself burst into flames near the neck. The spectators saw the flames licking the side of the balloon and enlarging the aperture every moment. As for the balloonist, Crosby, by the greatest good fortune he found himself over water when his position had become intolerable, and, jumping out, he fell with safety and was rescued by a boat.

Usually when anything goes wrong with an aeroplane in the air the aeronaut is hurt. The fall cannot be broken by any remnant of buoyancy in the contrivance. In the case of a mere stoppage of the motor there need be no serious result, because this does not affect the dynamic equilibrium of the machine, and it only means that a descent must be begun immediately at the angle of gliding of which the machine is capable. It is only serious when the aeronaut is not at a good elevation and consequently has only a small gliding radius. In other words, supposing he is at a height of 100 feet and the gliding angle of his machine is one in ten. In that case he can travel straight forward to a distance of 1000 feet before touching ground. If there is no clear landing-space for 1000 feet he will make a bad landing. If he guides his machine while gliding down and makes a turn he sacrifices some portion of his gliding radius, because a flying machine in turning cants up on one side and for the moment loses some of its lifting efficiency. There is no reason, however, why an aeronaut should not, when his engine stops, descend in spirals in order to reach any particular spot which attracts him as a landing-place. But if his planes and steering surfaces become disorganised during flight, then, no matter how well his engine may be working, only a miracle can save him. Knowing this, what must have been the sensations of the pioneers on very imperfect machines when they found that something refused to work or heard the splitting of wood and fabric which meant a broken plane or rudder?

There have been two or three cases of aeroplanes catching fire in the air. In the spring of 1910 an Algerian aviator

named Olieslagers was giving an exhibition of flying at Oran when the petrol of his motor in some way became ignited and the machine was soon enveloped in flames. Although in imminent danger of being burned, and, indeed, already suffering from the flames which reached his face and hands, the aviator never lost his presence of mind, but steered the machine to earth before the wings had been so impaired as to be of no further use.

That man of countless hairbreadth escapes, Santos-Dumont, had one of the most remarkable accidents on record. He was flying at St. Cyr in January 1910, when one of the wings of his monoplane broke, through the snapping of a stay, and the machine at once plunged towards the earth. The aviator never left his seat, and even tried to guide the fall of the machine; but whatever he did had no effect, for during its descent the aeroplane turned three complete somersaults.

These incidents, however, pale before that which befell a mechanic in America who was experimenting with some rather clumsy devices for flying in 1909. He was a Scandinavian, named Ulysses Sorensen, and he had made a gliding machine which, in emulation of the great Montgomery's experiments, he proposed to release from a balloon at a great height. He ascended by means of the lifting power of a balloon to a height of 3500 feet and then cut his machine adrift. He immediately discovered that the steering-rudder of his aeroplane was out of order and that he was helpless. The machine fell with great rapidity, turning over and over. When within a few hundred feet of the ground the fall was broken to some extent by the fact that the planes were then face downwards, and the machine took on a swift sidelong motion. Before it turned edge downwards the ground had been reached. The machine was smashed to pieces; but the aviator, although unconscious, was not severely injured. On regaining consciousness in half-an-hour he described his sensations as follows: "The rudder got jammed and refused to keep the aeroplane in a horizontal

position. We tipped forward, and then we turned over. After that we just kept spinning over until I thought we were spinning around like a top going sideways. I didn't have time to fall out, luckily; and anyway I was braced in. It seemed to last about a month, yet I did not once think of being killed. I never thought what would happen when I hit the ground. My mind was concentrated on getting the rudder in working order again, and I was tugging at the lever all the time."

Already the history of aerial navigation has provided instances of heroism and self-sacrifice. One of these was afforded by Hubert Le Blon, who, before he became an aviator, was a mechanic and motor-car driver. Le Blon was killed early in 1910 in circumstances that are related in another chapter. The incident now referred to took place at the Doncaster aviation meeting in October 1909, the first flying meeting ever held in England. On October 25th wind had prevented any exhibitions of flight. The crowd became impatient, and it was largely with a view to rewarding their long wait that Le Blon took the risk of making an ascent. The result was nearly disastrous both for himself and for some of the crowd. He ascended on his Blériot monoplane, and all went well for a few seconds, the ground being sheltered for some distance by the row of aeroplane sheds and a belt of trees. But, on getting to the end of this calm air, the wind caught the machine, and the spectators in the stands and enclosures saw Le Blon sway to and fro and then head straight for the rails. He poised for one terrible moment over the heads of the dense crowd of people lining the rails and then fell sheer into them from a height of about twenty feet. Nobody doubted that many were killed and injured. One thought of the propeller cutting its way through that mass of humanity, and of the petrol escaping and catching fire. This was what passed through the minds of the spectators, and it was with blank incredulity that they heard that the aviator was unhurt, that none in the crowd was injured, and that only the aeroplane was smashed. So certain had every one

been that the accident was serious that Delagrange, who was Le Blon's teacher and employer, shed tears of gratitude when he came on the scene and found the young aviator standing calm and unmoved in the midst of the broken fragments of his machine. It was a miracle. "He came right at us," said the people; "he rose, clearing the first rails, then dipped, then rose right up again over our heads. We thought he would fly into the trees. He looked quite cool. He waved us away to clear a space, and then he fell like a stone." Le Blon's own account of the accident was as follows: "The wind caught me on the right side and tilted the machine up. I could only save myself by heading in the face of the wind, and there was not time to land and stop before passing both lines of rails. There was a space beyond the crowd, if the people would give me room, and beyond that, only a few yards away, a hoarding and high trees. I stopped the engine, and steered over the people's heads with the impetus of my flight. I waved my hand to the people, and then dropped almost perpendicularly." But neither the words of the people nor the narrative of the aviator do justice to the incident. What had happened was this. Le Blon found himself driven by the wind towards the crowd. The first danger was that he might charge into them on landing, in which case he might himself have escaped from injury. Instead of landing, therefore, he instantly, and with almost incredible swiftness of mind, decided on his course of action. He took in the situation at a glance. Beyond the black crowd at the rails was a sparsely occupied space extending about twenty yards to the hoarding and the belt of trees. He was now flying into the teeth of the wind, and his progress was not swift with regard to the ground; yet the whole incident did not occupy more than two or three seconds. He had decided to fly over the heads of the people and risk what might befall in the limited space beyond. At the very least he knew he must have a bad fall: but he preferred that to driving his machine at thirty miles an hour into the crowd.

Having attained a position over their heads and looking down at them from a height of twenty-five feet he saw he must either fly on and dash into the hoarding or fall plumb to the ground. He did the latter by bringing up his elevator with swift and complete effect. The head of the machine took a downward course and fell, smashing to pieces. But the people were saved, and, by great good fortune, the aviator himself was unhurt.

It might be imagined by people innocent of experience of aerial navigation that an aviator's work consists of an unending series of exciting and critical moments. This is altogether a wrong impression. Naturally he obtains a skill which enables him to deal lightly with situations that would find the stranger to flight wanting; but this is true of motorists and of ship navigators also. Take, for instance, one occasional experience of flying—what is known as the "side-slip." This occurred in my own experience on one occasion when turning in a high wind, the wind blowing from the outside of the turn—*i.e.* blowing from the left during the execution of a turn to the right—I suddenly found that the left extremity of the aeroplane was being forced upwards at a very bad angle by a gust. I had been careful to avoid canting the machine up for the turn deliberately, for that is always dangerous with a wind from the outside of a turn; nevertheless, a gust caught the machine, and the aeroplane suddenly began to slip down towards the ground on my right. Such a situation always seems critical, and, indeed, is so if not quickly tackled. By turning sharply into the wind and by levering the machine up on the right, however, it was easy to recover balance with fifty feet to spare.

CHAPTER XI

SOME AIRSHIP ADVENTURES

THE first dirigible balloon was made by the brothers Robert under the direction of the Duke of Chartres in 1784, propulsion being obtained by means of oars, and the gas-envelope being fish-shaped. It is of great interest because, although it was the first dirigible balloon ever made, it was provided with a double envelope on the recommendation of General Meusnier, a member of the French Academy and an officer of Engineers, and this double envelope was the germ of the modern ballonnet system. Finding that there is a constant loss of gas which percolates through even the best qualities of fabric, and that there is, further, a waste of gas whenever the heat of the sun or the diminished atmospheric pressure in high altitudes causes the contents of the balloon to expand, General Meusnier designed an ingenious method of prolonging a balloon voyage. The loss of gas can be compensated by the discharge of ballast all the while the supply lasts, but it is found that the serious effect of the loss of gas or of a reduction in the temperature is that the balloon becomes flabby and cannot be driven through the air, while at the same time there is danger of the weight of the car becoming unequally distributed over the envelope and then of the whole structure breaking up. General Meusnier, therefore, showed how the envelope could be kept rigid, even though gas escaped or shrank in volume, by pumping air between the outer and inner envelope as required. In balloons of a later date, instead of the double envelope one or more air-bladders or ballonnets are built into the lower part of the main gas-envelope and are kept filled with air by a pump

actuated by a motor, automatic valves preventing any excess of distension. It is worthy of remark that at the first conception of the dirigible balloon practically every principle of construction was realised. There was very little improvement for a century, and the only thing that was lacking was the light motor.

An unbelieving world awaited every adventurer in aeronautical science. The Count de Lennox built an airship in 1834. It was cylindrical in form, with conical ends. Its length was 130 feet, and it was provided with a ballonnet. It was to be driven by twenty oars worked by men. Unfortunately it proved to be too heavy to ascend even without its crew, and the onlookers who witnessed the experiment in the Champs de Mars mobbed the inventor and smashed his airship to fragments.

Sixty years later an almost similar fate befell the rigid aluminium airship built by David Schwartz in Berlin, but in this case the balloon ascended and, with its motor, obtained a certain speed. Then the machinery going amiss the balloon made a somewhat ignominious and helpless descent. On landing it was blown over by the wind, a crowd of spectators completing its destruction.

The brief excursion into the realms of science and the air by a certain French hatter named Petin is worth recording. He designed an airship consisting of four spherical balloons sustaining a platform 200 feet in length by 30 feet in width. It was to be driven by screws which the inventor proposed to work by hand or by some mechanical means. The lack of a motor was the principal obstacle at that date, 1850, and the steam-engine would have been too heavy. Petin made models of his airship and went about France raising subscriptions. His enthusiasm won him plenty of support, including that of the famous novelist Theophile Gauthier, who wrote in the following terms of the invention:—

"The grand dimensions of this machine approximating those of the nave of Notre-Dame or of a man-of-war should

not astonish. These gigantic proportions are a guarantee of security . . . if one may be permitted to affirm anything in the present state of the project one advances nothing that is not perfectly logical and reasonable in saying that from to-day the problem of aerial navigation is solved, or else all the known physical laws are false and statics do not exist."

The ship was made, but the police would not allow an ascent. Petin left France and went to England, and then to America, where he made many balloon ascents, on two occasions

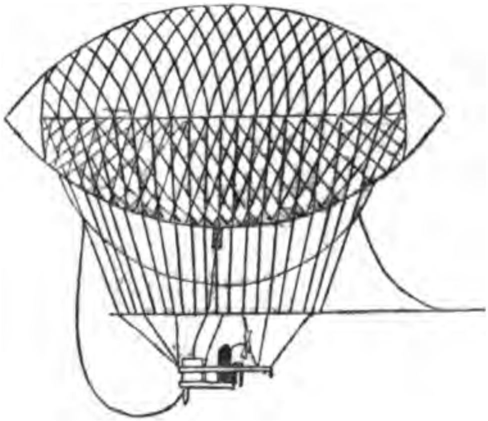


FIG. 8.—GIFFARD'S BALLOON, 1852.

The first airship driven by an engine.

falling into the water and having narrow escapes from death. These wettings seem to have damped his ardour, and the hatter returned to France and resumed his commercial career.

F. A. Gower made experiments in France in 1883, and, writing to Professor Tyndall, claimed to have succeeded in driving a large balloon against the wind by steam-power. Gower was blown over the sea two years later in his balloon, and was never found.

Although numerous attempts had been made before his time, Henri Giffard was the first to demonstrate the prac-

ticability of dirigible ballooning. He has been called "the Fulton of aerial navigation." In 1852 he built an elongated balloon, to the stern of which he attached a rudder. The accompanying diagram gives a general idea of Giffard's airship. The engine was worked by steam, and the propeller-screw was very much on the lines of a windmill's sails. The balloon was 150 feet long by 40 feet in diameter. It was inflated with 88,000 cubic feet of coal-gas. The engine weighed 3 cwt. and developed 3 h.p., which may be compared with petrol motors, some of which develop 1 h.p. for 1½ lbs. of weight. Giffard's attempt was, be it said, a tremendous adventure into the unknown. He realised the danger of putting a furnace close to the gas-envelope, and he adopted the device of turning the chimney downward, producing a draught by the steam blast as in a locomotive engine.

The ascent took place on the 24th of September from the Hippodrome in Paris in a strong wind, and it was successful to the extent that Giffard was able to demonstrate clearly that his ship had an independent speed of five to seven miles per hour, which enabled him to steer. In that ascent he rose to an altitude of 6000 feet, and made a safe descent at Elancourt.

In 1855 Giffard built a larger balloon which confirmed the results already attained, but lacking a light motor it was impossible for him to make any further progress. Dupuy de Lôme's airship, made in 1870, was really no advance on Giffard's, and was of very similar design, but the large screw-propeller was worked by manual power.

The airship of Renard and Krebs, made in 1883, marks the next important step. It was of the more scientific shape known as fusiform; the car was strung up quite near the balloon-envelope, thus minimising the air-resistance; and it was driven by an electric motor. With this vessel on August 9, 1884, the first voyage in a complete circle was made in the air. A speed of fourteen miles per hour was attained.

France was aroused to enthusiasm by this achievement, which promised, in the imagination of the fervid countrymen of Renard and Krebs, a new dominion over the air and a new and

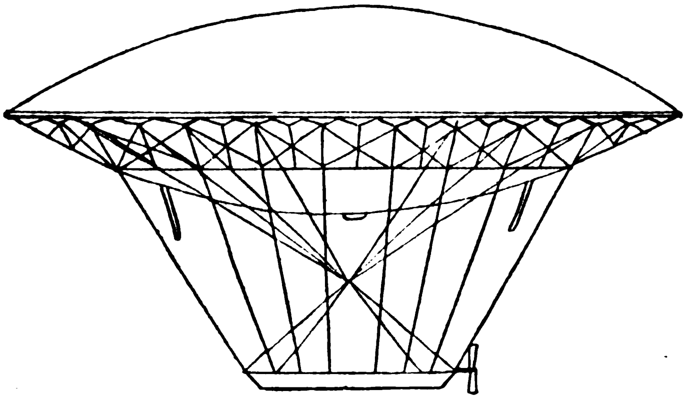


FIG. 9.—DE LÔME'S AIRSHIP.

mighty power in war; and although the experiments were all made in perfect weather, there is no doubt that the airship was a great advance on all its predecessors. The inventors kept the constituents of their electric battery a secret.

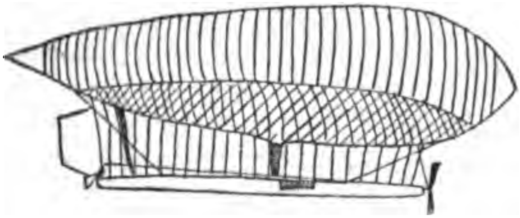


FIG. 10.—RENARD AND KREBS' BALLOON, 1884.

Driven by electricity. The first airship for which success can reasonably be claimed.

Germany, at that time keenly watchful of French progress in any matter that had possible military application, was not idle. Dr. Woelfert, of Berlin, in 1886 made a cigar-shaped

balloon driven by a Daimler benzine motor of 8 h.p. A horizontal propeller for vertical movements was placed beneath the car, and the airship was driven by a two-bladed aluminium screw. There were partially successful trials with this airship in 1886 and in the spring of 1887, but on June 14th of that year Woelfert made a disastrous experiment with a benzine vaporiser of his own design. This set fire to the ship in mid-air and it exploded, Woelfert and his assistant Knabe being killed.

The work of Santos-Dumont and the fatal accident to Severo are referred to in another chapter. Two terrible airship disasters illustrating the dangers that attended aerial navigation in its infancy occurred in 1909 and 1910. On September 25, 1909, "La République," a French military dirigible balloon of the semi-rigid type, was wrecked in the air, near Avrilly, through a propeller-blade flying off and tearing through the gas-envelope. The occupants of the balloon, Captain Lucien Marchal, Lieutenant Chaure, Albert Reau, and Vincenot were killed. On July 13, 1910, a private German dirigible balloon, the "Erbslöh," designed by the famous balloonist of that name, burst in the air at a great height near Leichlengen. Erbslöh, a friend named Poelle, two engineers, Franz and Hollp, and the mechanician Spiecks were instantaneously killed.

The first dirigible balloon seen in the air at Vienna was the handiwork of two lads named Renner, aged sixteen and seventeen years respectively, and the story of their experiment is worth preserving. They were the sons of an acrobat, and their idea in making the balloon was simply to enliven the proceedings at a fair. They had no knowledge of aeronautical science, but with their father's help and their own tremendous perseverance they made a balloon and fitted it with effective steering and driving machinery. The fame of their achievements travelled far outside their own circle, and an Austrian newspaper invited them to Vienna to give a demonstration. Forty thousand people assembled to witness the trials; the Emperor Francis Joseph was present with the Archdukes

Rainer and Eugene. The balloon proved to be a very primitive construction of the non-rigid type, with the propeller in front, a rudder, and a horizontal stability plane. It had no elevator, but the boys could change the angle of the balloon by taking up different positions in the car. The first trials were so far successful that the Emperor congratulated the lads. On the following day there was a slight accident, of which advantage was taken by the Austrian military aeronauts to treat the whole affair with scorn. But seeing that, for their part, they had been studying the airship question for years and had done nothing at all, their contempt of the Renner lads appears to have been misplaced.

CHAPTER XII

THE STORY OF ZEPPELIN'S LIFE DEVOTION

NO matter what the future has in store for aeronautical science, no matter what discoveries are made revolutionising present methods, the name of Zeppelin will always hold a big place in its annals. His is one of the great heroic figures in aeronautical progress. The devotion of his life and the tremendous character of his projects and achievements surround his name with extraordinary interest.

Ferdinand von Zeppelin acquired his taste for ballooning during the American Civil War. He was a young officer in a volunteer German corps on the Union side, and while attached to the army of the Mississippi he made a few ascents in captive observation balloons. On returning to Germany he soon saw service again in the war against Austria in 1866, in which he served with distinction. Four years later in the war against France he had a command of Würtemberg cavalry. Again he won distinction, this time by riding with three or four comrades far into French territory and obtaining valuable information. He was the only survivor. On retiring from the colours he devoted himself to his pet project of airship construction, spending his own money freely in experiments and starting a company for the purpose of raising further money when his own failed. In 1895 Zeppelin was besieging the German War Office experts with appeals for official aid. At this time he was regarded as something of a monomaniac, and his scheme for an airship having been submitted to the Kaiser was referred by the latter to a committee, who returned it to the supreme War Lord marked "impracticable." An American millionaire,

the owner of a great newspaper, replying to Zeppelin's request for help, said that he had no time or money to waste on "crazy inventors." Zeppelin was able, however, to begin work on an airship in 1898, and it was ready for trial ascents in July 1900. In carrying this project out he had a good deal of support from King William of Würtemberg.

From the moment of the first trial of this enormous airship Zeppelin had the hearts of his fellow-countrymen. From that instant he became one of the most conspicuous figures of his time, and his gigantic battle with misfortune, which came in the shape of accident and disaster to successive airships which he built, was watched with fascination. His history is a long record of misadventure and disaster interspersed with occasional triumph.

Zeppelin's first balloon was the largest that had ever been made, and it differed from previous dirigible balloons in being of the rigid type. As already explained in another chapter, Zeppelin was preceded by Spiess in the conception of this idea, but Spiess's project was never carried out.

It is a debatable point whether Zeppelin was or was not anticipated by David Schwartz in the idea of the rigid dirigible balloon. Schwartz began to build his aluminium airship at St. Petersburg in 1895, but it never made an ascent, meeting with an accident during inflation. Then, under the auspices of the German Government, a second balloon was built at Berlin. Before it was completed Schwartz died, leaving all his plans to his widow, who continued the work. The dimensions of the new balloon were as follows: Length, 134 feet; diameter, 42 feet; weight, 5720 lbs. It was driven by a motor of no more than 12 h.p. There were numerous devices for steering and balancing, but the builders are said to have made a great muddle of the original designs. The widow of the inventor waged a great battle against every conceivable form of discouragement, and as the day for the first trial approached, she alone was confident of the result. While other spectators were predicting

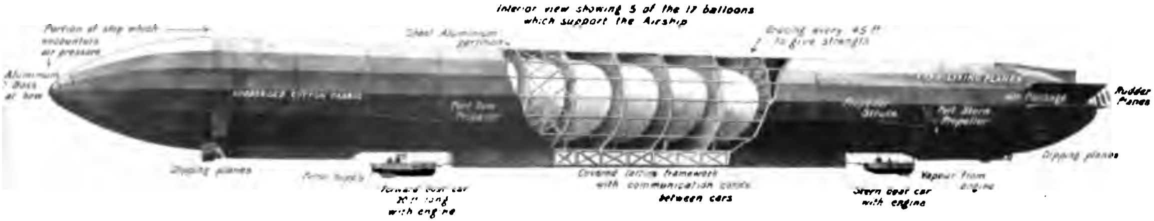
that the airship would never rise it actually began to tug at the ropes which held it to the ground, much to the amazement of those who had been remarking upon the enormous weight of the metal case. Their attitude, indeed, was precisely that of the critics who said of the first iron vessel that it could not possibly float.

Jaegels, the engineer, although not an experienced aeronaut, had charge of the airship, which rose into the air and began to hold its own against a breeze. Unfortunately, the mere task of attending to the motor and the other contrivances proved too much for one pair of hands, and Jaegels's wits deserted him. He pulled open the valve and begun to plunge towards the ground. He managed to jump out in time to save himself from being involved with the machinery, and was scarcely hurt; but the airship itself, which had cost £10,000 and had taken four years to build, was completely wrecked.

How anxious others were to have the credit of initiating the idea of the rigid airship is shown by the fact that in 1910 a watchmaker named Lange, of Mühlberg, on the Elbe, declared that Zeppelin had stolen the idea from him. He was sentenced to five months' imprisonment for slander and attempted extortion, Zeppelin himself being called as a witness.

In the first Zeppelin airship the gas-containers, of which there were sixteen, having a total capacity of 400,000 cubic feet, were enclosed in a long aluminium framework covered with linen and silk. The interior was divided into sections, each of which contained one of the gas-bags. The total length was 420 feet, and its diameter was 38 feet. There were two cars, each carrying a motor of 16 h.p.; and each motor drove two four-bladed screw-propellers. A sliding weight was used to raise or lower the front of the balloon, so that when in motion it would be driven slightly up or down apart from the equilibrium obtained by the buoyancy of its gas.

The construction of the outer envelope was a matter of supreme importance. It provided a smooth surface, protected



THE ZEPPELIN AIRSHIP

This drawing of the Zeppelin airship in section gives a very clear idea of the construction of the famous dirigible balloon which remained until almost the end of 1909 the only rigid type extant. The object of dividing the gas into seventeen compartments was to retain the vessel's efficiency even should one part of it become disabled. See description on page 130.

the gas-envelope from injury, and, above all, maintained the shape of the balloon. In the non-rigid and semi-rigid types loss of gas or the contraction of gas due to cold is accompanied by the shrinkage of the envelope, when the pressure against the atmosphere makes a huge "pocket" in the balloon and it becomes impossible to make any headway. In these circumstances the airship becomes helpless in the wind. Within certain limits the ballonnet employed in non-rigid and semi-rigid airships obviates this difficulty, for by pumping air into the ballonnet, which is inside the gas-envelope, the space caused by shrinkage of the gas is taken up and the outward form of the balloon is maintained.

The weight of Zeppelin's rigid framework was a serious drawback. It necessitated a balloon of unprecedented size in order that there might be a sufficient margin of lifting power to carry it. Even so, it could not be made of any great thickness, and was so weak, in fact, that Maxim pointed out that the retention of its shape was largely dependent upon the retention of the full amount of gas in the envelopes. As the gas-envelopes lost gas, said Maxim, the resisting power of the aluminium case became less.

The building of this monster divided aeronauts into two schools, the pro-Zeppelins and the anti-Zeppelins. Surcouf, the famous French airship builder, declared that the rigid frame was an absurdity. It was very curious that both he and Maxim on the day before the trial of one of Zeppelin's later airships predicted disaster, and their prophecy was fulfilled to the letter.

The first ascent was made in July 1900, when the winch that worked the sliding weight was broken, and the whole balloon was so bent that the propellers could not be properly worked. The maximum speed attained was only 8½ miles per hour, and it was impossible to steer, as the ropes used for this purpose became entangled. On descending to Lake Constance, where the balloon had its floating shed, further

injury was sustained by running on a pile. On October 31st a further attempt was made, when a speed of 20 miles an hour was reached. This exceeded that obtained on any previous dirigible balloon, and accordingly Zeppelin was hailed throughout Germany as the conqueror of the air and as the inspired inventor who was to give his Fatherland the world-wide dominion which the patriotic desired.

From that time Zeppelin's career consisted of alternate disappointment and success, disaster and triumph. No one man, with the exception of Santos-Dumont, had made so many airships as Zeppelin, and the Brazilian's little fleet consisted of comparatively insignificant vessels, its aggregate value not equalling that of one Zeppelin.

The cost of a Zeppelin airship was, indeed, heavy, and it took all the funds he was able to raise, helped by the fact that German factories supplied him with materials at cost price, to construct the second airship, with which a first flight was made in January 1906. On that occasion the weather favoured the ascent, yet within a few minutes a gusty wind sprang up which tested the endurance of the airship and the stability and the skill of the aeronaut to the utmost. It managed, however, to make a safe descent, but only to be destroyed during the night by a gale.

Within nine months the Zeppelin III. was afloat. This was a much more powerful airship than its forerunners, and in spite of an early misadventure—one of the propellers flying off and penetrating the gas-envelope—it was a great success. This vessel afterwards became the nucleus of the German aerial war fleet, and was known as His Majesty's airship Zeppelin I. One of its achievements was to carry eleven passengers for a distance of sixty-nine miles. Zeppelin's next misfortune was the almost complete destruction of his balloon-shed by a storm. His career at this time was an epitome of mankind's struggle to achieve the conquest of the air. Only men of his indomitable character have been able to

persist in the face of the constant discouragements. In his case it was the more remarkable, since at the time we are now dealing with he was no longer young or even middle-aged, but was on the verge of man's allotted span.

In June 1908 the Zeppelin IV. made successful voyages, and on July 1st she astonished the world with her famous cruise into Switzerland. Two weeks later—on August 4th—the Zeppelin IV. went out on an attempt to make a 24-hour trial-trip, a standard of achievement that had been set by the German War Office. Three weeks before Zeppelin had planned to make this trip, but a sudden squall drove the airship on to the balloon-shed, damaging both. On this occasion the airship travelled from Friedrichshaven to Mayence and back *viâ* Basle, Strasburg, Mannheim, and Stuttgart, the voyage occupying 21 hours, a world's record. But on landing after its victorious career it met with disaster, being destroyed by fire.

To aid Zeppelin in the hour of his crowning misfortune then became his country's dominating passion. The Government placed £25,000 of the intended purchase-price for Zeppelin IV. at his disposal without delay. Rich and poor subscribed to a Zeppelin fund, and in a few weeks £300,000 had been raised.

His next airship was the No. III., much enlarged and improved. The vessel's length was 453 feet, and it was estimated to be large enough to carry a fuel supply for forty-eight hours. It was driven by two motors, each of 85 h.p., and it was hoped that its speed would be over thirty miles per hour.

Early in the following year the Zeppelin airship dockyard handed the vessel over to the military authorities, who at once proceeded to conduct trial-trips and secret experiments. Meanwhile, Zeppelin himself was navigating another airship, and on March 19th he took twenty-six passengers for a voyage of 150 miles.

The Kaiser had honoured Zeppelin in one way and another, and in one characteristic speech he called him the "greatest German of the twentieth century." He conferred on him the

Order of the Black Eagle, and embraced him three times, exclaiming, "Long life to his Excellency Count Zeppelin, the conqueror of the air!" The King of Würtemberg, on the occasion of the marriage of Zeppelin's only child, a daughter, offered as his wedding present a royal decree whereby the bridegroom became entitled to the suffix "Zeppelin," thus perpetuating the honoured name. And in the following year the Kaiser raised Zeppelin to the dignity of knighthood in the Prussian Order of Merit. Throughout the Fatherland the face most familiar to the populace by means of photographs, plaster models, and even devices on handkerchiefs, after that of the Kaiser himself, was Count Zeppelin's. But while he was enthroned in the hearts of his countrymen he continued to wage his battle with misfortune. Comedy that was almost tragedy characterised one of his adventures. In June 1909 he made a voyage of over 900 miles in 38 hours, and it was announced that he would travel to Berlin. The vessel was awaited by a vast multitude on the Templehof Parade-ground on June 1st, and the Kaiser himself, advised by a telegram signed "Zeppelin" (which was afterwards shown to be a forgery), prepared to welcome the aeronaut. The telegram was sent to the Berlin Airship Battalion in order that they should hold themselves in readiness to assist the landing. But meanwhile the airship had met with an accident. She collided with a tree, sustaining so much damage that she could afterwards only use one of the motors. The Kaiser, disappointed at the non-arrival, and not knowing the reason, sent a telegram the terms of which unmistakably expressed a certain amount of displeasure.

It was not until August 1909 that Berlin celebrated "Zeppelin Day," welcoming the arrival of the airship after its journey of 475 miles. On that day the sober Berliners went almost mad with enthusiasm. The Kaiser and Kaiserin personally greeted Zeppelin, and to complete the picture Orville Wright and his sister were present.

Three weeks before, the Zeppelin II. had been badly damaged after a long voyage, and in the following year, on April 26th, another of his airships suffered partial wreckage. But all these accidents fade into insignificance before the dramatic wreck of the first Zeppelin aerial passenger vessel. This aerial liner, which had already made upwards of thirty passenger trips before the fatal day, was carrying thirteen passengers, each of whom had paid a heavy fee for the privilege of being one of the first to enjoy this novel method of travel. The car was fitted up as luxuriously as a trans-continental railway coach. It carried the first aerial restaurant ever organised. The voyage lasted for nine hours, during which the airship had to contend with strong wind, against which, owing to the failure of one of its motors, it proved almost helpless at a critical moment. I cannot do better than quote from the narrative of one who was a passenger:—

"All the afternoon it had been a Titanic struggle between the great white airship and the rapidly rising gale, and even when, a hundred miles from our garage, and with the petrol rapidly giving out, it became clear that an accident of some sort was humanly inevitable, we could not help watching the contest with fascination. Now rocketing upwards, now plunging down to within a hundred feet of the earth, the Deutschland, like a sentient being, sought in vain some level where she might find mitigation of the fury of the wind.

"Suddenly the port stern-propellers stopped. There was a defect in the motor. The wind was freshening fast, and with one propeller ineffective it was difficult to steer. We decided we should try to make Muenster, where, with the help of the garrison, we could land on the military exercising ground and repair the motor. The wind grew stronger. We could not make Muenster. We dare not now turn and fly before the wind, however, or the airship would lose steerage way. So, doggedly she was turned almost in the teeth of the gale to weather the storm in the air. 'We might, perhaps, reach

Osnabruck,' said Dr. Colsmann, a director of the airship company on board, 'where are also military who could help us to land.' Telegrams warning them of our possible arrival were thrown from the ship. And the swerving, diving, rain-beaten airship fought on inch by inch, sloping steeply first forward and then aft as we rose and fell in the storm. It was very cold. Icy showers fell in torrents round us. Often we hung motionless for a quarter of an hour with the propellers revolving at full speed, powerless against the resistance of the wind.

"Our petrol was now failing. We had been nearly nine hours in the air, instead of three. Just before five o'clock we saw dense black rain-clouds ahead. A moment later we plunged into them and a white fog closed round us, shutting out everything from our eyes. So we continued for half-an-hour. Then the petrol gave out and the whirling propellers faltered and stood still. Almost simultaneously we broke through the floor of the cloud, and there, only a few feet below our bows, was a hill covered with a dense fir forest.

"Our water ballast was exhausted. Some of us were ordered to run aft along the narrow gangway inside the keel of the airship to attempt to bring her to the ascending position. It was too late. A downward eddy of the gale seized the swaying ship, and down we crashed into the tree-tops. There was a rending, tearing sound. The airship shivered and struggled as if to rise. There was another crash, and the splintered tree trunks stabbed through the floor of the cabin and into the hinder part of the balloon, ripping the gas compartments in all directions. There we stuck fast, held by the branches of the trees. Had we with the same force struck the open ground scarcely any one in the airship could have escaped serious injury."

In 1910 Zeppelin suggested a voyage by airship to the North Pole, and an expedition of inquiry, of which Prince Henry of Prussia was a member, went to Spitzbergen to make experiments and investigations.

[Illustrations Bureau

DÜSSELDORF PHOTOGRAPHED FROM A ZEPPELIN AIRSHIP

One of the First Regular Airship Services Crossing the Rhine.

I have given as briefly as possible the history of the principal struggles of this remarkable man. Many more details could have been given, and the history could have been carried farther on to the present time, but for the purposes of this book it is unnecessary. Before closing the chapter, however, it will be well to state, in Zeppelin's own words, his theory of aerial navigation and his idea of the advantages of the rigid dirigible over other types.

"The first thing necessary," he wrote, "is to have two independent motors. Whereas a train suffers no damage from stoppage, and a steamer at worst remains afloat, an airship, should its single motor stop, must descend. It can, of course, choose its landing-place to some extent, for it can, like an ordinary spherical balloon, drive before the wind while the navigator seeks a landing-place. But at the best, in any but the calmest weather, landing without being able to keep the head of the vessel to the wind probably means disaster. Equally there is danger of disaster if the gas-envelope loses shape, thereby rendering the whole vessel unsteerable. But the airship built on the rigid principle avoids these dangers.

"Once an airship's speed is greater than any opposing wind, speed becomes of secondary importance compared with radius of action. An airship which can fly at 33 miles an hour for fifty hours, covers 1650 miles; whereas an airship which travels only 27 miles an hour, but keeps up its flight for one hundred hours, will cover 2700 miles. It must be understood that speed, in these calculations, means speed through the air, which is a different thing from speed in relation to the country underneath. Every one knows that so long as there is no wind a balloon stands still, and that its movements, if any, are entirely dependent upon the strength and direction of the wind at a given moment. During a violent storm the balloon will keep in the same external shape which it has during a calm. I am speaking, of course, of the ordinary spherical balloon without a motor. This balloon is really part

of the air and travels with it. In that respect, the mightiest balloon is in the same position as a soap-bubble. So long as the soap-bubble is attached to the pipe through which it is blown, it takes wonderful gherkin-like shapes under the pressure of every breath or draught. But once it is free, it becomes a perfect sphere. From this may be deduced an enormously important factor for air-navigation. When a motor airship floating free in the air sets its engines and propellers to work, it can move through the surrounding air in any direction with equal speed, as in no direction does it suffer any resistance other than that of the air.

"It has been said that such large airships as mine cannot ascend to great altitudes; but the size of an airship has nothing to do with this: the real question is how far the ship can spare weight or ballast in relation to its original carrying capacity. Every time an airship sacrifices the hundredth part of its original weight it will rise about 90 yards. Take, for instance, a small airship weighing only 4800 lbs. Such a ship equipped with an 85 h.p. motor will at most be able to carry 1000 lbs. of benzine for a twenty-hours' voyage. If it wishes to ascend 1350 yards, it must leave behind or sacrifice 720 lbs. of benzine, or it must have already consumed that quantity, thereby further reducing its capacity for flight to five hours, which, for practical purposes and reliability, is hardly enough. A great airship weighing 32,000 lbs. with a normal benzine supply for one hundred hours will, though it rises to 1350 yards, still have a reserve supply of thirty-six hours' benzine, or nearly twice as much as the smaller airship can carry even when flying close to the ground. For that reason, for travelling at great elevations, a big airship will always have advantages over a small one. Any mathematician can easily calculate the height to which a particular airship can rise without too much reducing its carrying capacity, and there is not the least need for him to check his computation by practical experiment."

CHAPTER XIII

SANTOS-DUMONT—A STORY OF FAILURE, ADVENTURE, AND TRIUMPH

IN 1898 the whole world heard that a Brazilian, a reputed millionaire, a young man named Alberto Santos-Dumont, was having a navigable balloon made in Paris. Those who can throw their memory back to that time will recollect that a paragraph in the newspapers concerning any proposal to build an airship was regarded as a mere curiosity not worth the passing thought of a busy man. Occasionally items of news concerning "a mad German" of the name of Zeppelin crept into English papers at times when news was scarce. These paragraphs did not, perhaps, interest many people. So when the name of Santos-Dumont was first seen in the newspapers it made no impression. Most people refused to believe that such a person existed, and those who did believe it concluded that he was mad.

To understand the man who initiated the modern airship movement in France, and, later, made the first officially observed aeroplane flight in Europe, we must briefly sketch his career. He has told us the story of his life in his book *My Airships*, and as an introduction to this work he has written a curious fable in which most readers will find evidence that it is in some measure a report of actual conversation. It tells of the discussions of "two young Brazilian boys," Pedro and Luis. After three or four topics in which Pedro expresses the scepticism of the average man as to new ideas, and Luis replies in the sanguine spirit of the dreamer and the discoverer, the following climax is reached: the boys have just seen a steamboat for the first time, and are talking about it to an old planter.

"Pedro," said Luis, "will not men some day invent a ship to sail in the sky?"

The common-sense old planter glanced with apprehension at the youth's face, flushed with ardour.

"Have you been much in the sun, Luis?" he asked.

"Oh, he is always talking in that flighty way," Pedro reassured him. "He takes pleasure in it."

"No, my boy," said the planter, "man will never navigate a ship in the sky."

"But on St. John's Eve, when we all make bonfires, we also send up little tissue-paper spheres with hot air in them," insisted Luis. "If we could construct a very great one, big enough to lift a man, a light car, and a motor, might not the whole system be propelled through the air, as a steamboat is propelled through the water?"

"Boys, never talk foolishness!" exclaimed the old friend of the family hurriedly as the captain of the boat approached. It was too late. The captain had heard the boy's observation; instead of calling it folly he excused him.

"The great balloon which you imagine has existed since 1783," he said; "but, though capable of carrying a man or several men, it cannot be controlled—it is at the mercy of the slightest breeze. As long ago as 1852 a French engineer named Giffard made a brilliant failure with what he called a 'dirigible balloon,' furnished with the motor and propeller Luis has dreamed of. All he did was to demonstrate the impossibility of directing a balloon through the air."

"The only way would be to build a flying machine on the model of the bird," spoke up Pedro with authority.

"Pedro is a very sensible boy," observed the old planter. "It is a pity Luis is not more like him and less visionary. Tell me, Pedro, how did you come to decide in favour of the bird as against the balloon?"

"Easily," replied Pedro glibly. "It is the most ordinary common sense. Does man fly? No. Does the bird fly? Yes.

Then if man would fly let him imitate the bird. Nature has made the bird, and Nature never goes wrong. Had the bird been furnished with a great air-bag I might have suggested a balloon."

"Exactly," exclaimed both captain and planter.

But Luis, sitting in his corner, muttered, unconvinced as Galileo, "It will move."

Let Luis stand for Alberto Santos-Dumont and you have the man who is the subject of this chapter.

Santos-Dumont relates that among the thousands of letters which he received after winning the Deutsch prize for steering his balloon round the Eiffel Tower was one that gave him particular pleasure. He quotes from it:—

"Do you remember the time, my dear Alberto, when we played together 'Pigeon flies.' It came back to me suddenly the day when the news of your success reached Rio. 'Man flies,' old fellow. You were right to raise your finger, and you have just proved it by flying round the Eiffel Tower. They play the old game now more than ever at home, but the name has been changed and the rules modified since October 19, 1901. They call it now 'Man flies,' and he who does not raise his finger at the word pays forfeit."

Santos-Dumont first went to Paris in 1891. He there came across professional balloonists who quoted such extravagant prices for an ascent that he abandoned the idea. Subsequently, at home, he picked up a volume entitled *Andrée—Au Pole Nord en Ballon*. The technical descriptions in this book revealed to Santos-Dumont the possibility of making a dirigible balloon at reasonable cost, and he resolved to meet Lachambre, the builder of the Andrée balloon. This resolution he kept, with the result that it was not long before he made his first ascent in a spherical balloon; and he liked that so much that he had a balloon made for himself. Despite the opposition of manufacturers who assured him that his balloon would be too small,

he had one made of the capacity of 4104 cubic feet, the smallest man-lifting spherical balloon on record. All its equipment was, of course, proportionate. The envelope was made of thin Japanese silk, which proved, contrary to professional opinion, thirty times stronger than was, according to the theory of strain, necessary. By this time Santos-Dumont had become an experienced balloonist, but all the while he was ambitious to make a steerable balloon. Whenever he mooted the question he was laughed at, and when he suggested using a petrol motor he was regarded as a madman and was told that he would certainly blow himself up. "But," said Santos-Dumont, "I will use this light and powerful motor. Giffard had no such opportunity."

He was aware, of course, that certain light steam motors are lighter even than petroleum motors, but the boiler always ruins the proportion. With one pound of petroleum you get 1 h.p. for one hour. With the best steam-engine you require many pounds of water and fuel to obtain the same result.

In making his first airship Santos-Dumont received only opposition from professionals. He had to start his own workshop, obtain his own workmen, and teach them what to do against their many deep-rooted prejudices. He had to buy his own materials with great difficulty. He subjected his motor—one of 3½ h.p. that weighed 66 lbs.—to the severe test of running it in the Paris-Amsterdam automobile road race in 1897. The result pleased him immensely. He could keep well up with the pace, and the motor was not injured by use on the roads.

The first steerable balloon made by Santos-Dumont was cylindrical in shape with pointed ends, 82½ feet long, 11½ feet in diameter, and with a capacity of 6354 cubic feet. To cut down weight he found that he could not give more than 66 lbs., including varnish, to the envelope. He therefore decided to use Japanese silk. The maker, on seeing the order, declined

to be a party to such rashness. However, he finally gave way Santos-Dumont then prepared his basket, motor, propeller, rudder, and machinery. He subjected everything to prolonged tests, and, trivial as his efforts now seem to us, it is evident, when we remember that he had practically no previous data to go upon, that he was inspired by positive genius. One of the cleverest ideas in this balloon was the system of shifting weights, by means of which he hoped to keep the balloon properly balanced. He placed two bags of ballast, one fore and one aft, suspended from the balloon-envelope by cords. By means of lighter cords each of these two weights could be drawn into the basket, thus shifting the centre of gravity. If he pulled in the fore weight, for instance, the stem of the balloon would point diagonally upwards. The making of this balloon occupied several months. The work was done in a little machine-shop in the Rue du Colisée, close to the first offices of the Paris Aero Club.

In September 1898 Santos-Dumont prepared to make his first voyage. Members of the Aero Club were alarmed at the danger he sought to run, and tried to persuade him to use an electric motor instead of the explosion motor. The inflation took place on September 18th at the Jardin d'Acclimatation. Owing to the stupidity of his assistants, who could not understand the difference between a dirigible and an ordinary balloon, he was obliged to ascend on the windward side of the clearing. He should, of course, have gone up from the opposite side, driving against the wind, when he would have cleared the trees. As it was, not being in a helpless aerostat, he had no sooner started than his airship drove against the trees. He was weak to yield to the advice of the assembled aeronauts, but he had the satisfaction of being able to say, "I told you exactly what would happen." He was not the man to waste time in regrets, but two days later started from the same open space, this time choosing his own starting-point. Passing easily over the tops of the trees, he at once began sailing around

them, to the great admiration of the assembled Parisians, who have ever since that day idolised him. Everything went well on that journey until he made the mistake of ascending to too great an altitude for the capacity of his balloon. On descending to a lower altitude the envelope naturally became flabby and began to fold up in the middle. The tension of the cords became unequal, and the balloon-envelope was on the point of being torn by them. The descent became a fall. Seeing some boys flying kites, an idea struck Santos-Dumont. He called to them to grasp the end of his guide-rope and to run with it against the wind. The effect of this was immediate. The velocity of the fall was lessened, and a bad shaking prevented. This was Santos-Dumont's first escape. Writing about this incident, he says that he felt nothing but elation afterwards. "The sentiment of success filled me. I had navigated the air. I had performed every evolution prescribed by the problem. The breakdown itself had not been due to any cause foreseen by the professional aeronauts."

He had been through a moment of great peril, for while over the house-tops of Paris, when the balloon began to double up, he realised that the ropes, working at unequal strength, might begin to break one by one.

It is difficult for us to realise the boldness of this experiment, which, in spite of all the precautions the inventor took, contained many elements of grave danger. Previously, he had tried how his motor would work out of its usual firm bed by suspending it under some trees to see if the vibration would shake it to pieces or break the ropes. He then discovered that there was less vibration this way than when the motor was travelling on the ground. He described this as his first triumph.

"I will say frankly," he afterwards wrote, "that as I rose in the air on my first trip I had no fear of fire. What I feared was that the balloon might burst by reason of its internal pressure. I still fear it."

He explains the vital difference between spherical and dirigible balloons in this respect. The former are always open at the neck. The latter are entirely dependent upon automatic valves and upon keeping on a fairly level keel.

The second Santos-Dumont airship was built in the spring of 1899. This was a little larger than the first, and it had one or two slight improvements. The first ascent was during a shower of rain. This caused great contraction of the hydrogen. Then, before the air-pump could distend the ballonnet, a gust of wind doubled the airship up and tossed it into the trees. All this was occasion for further pleadings from his friends that he should give up his "foolhardiness." However, he persevered and made his third airship, which had a shorter and thicker gas-container and a capacity of 17,650 cubic feet. With this he had a most successful voyage on September 13, 1899, using his propeller and shifting weights to obtain ascensive and descensive movements without sacrificing gas or ballast.

The Santos-Dumont No. IV. had the propeller in the stem instead of in the stern. The driver sat on a kind of bicycle seat. He made many voyages on this airship, one of which was witnessed by Professor Langley, who gave him much encouragement. In the No. V., which was an enlargement of No. IV., he entered for the Deutsch prize of 100,000 francs. In his first attempt on July 13, 1901, he successfully turned the Eiffel Tower, but on his way back his motor stopped and the airship was carried into some chestnut trees in the park of Edmond de Rothschild. All the spectators thought the aeronaut was hurt, but they found him standing in the basket high up in the tree, while the propeller rested on the ground. This happened very near the house of the Princess Isabel, the daughter of Don Pedro of Brazil, a compatriot of Santos-Dumont, from whom a few days later he received the following letter :—

"*August* 1, 1901.

"MONSIEUR SANTOS-DUMONT,—Here is a medal of St. Benedict that protects against accidents.

"Accept it, and wear it at your watch-chain, in your card-case, or at your neck.

"I send it to you, thinking of your good mother, and praying God to help you always and to make you work for the glory of our country. (Signed) ISABEL, COMTESSE D'EU."

The superstitious will think that this "mascot" did the aeronaut good service. On the 8th of August, 1901, during a voyage with which Santos-Dumont attempted to win the Deutsch prize, he had one of his marvellous escapes. The balloon lost gas, and in the return from the Eiffel Tower it shrank so much that the suspension wires sagged and the propeller fouled some of them. He stopped the motor, and immediately the wind began to carry him back towards the Tower. All this time the balloon was rapidly descending, and lost buoyancy to such an extent that one end was quite empty, fluttering about in the wind, while the airship's stem pointed upwards. It seemed that the wires on which all the weight depended must certainly break. Santos-Dumont was descending towards the Seine Embankment, and at the last critical moment the full end of the balloon struck the roof of the Trocadero Hotel. The navigator found himself hanging in his wicker basket high up in the courtyard of the hotels, supported by the airship's keel, which rested on the roof of a lower building. The keel, in spite of his weight and that of the motor, resisted wonderfully, and that saved his life. After a long interval he was rescued by firemen, who lowered a rope from above.

The Santos-Dumont No. VI. was an improvement on its predecessors, chiefly with regard to the ballonnet, to which the inventor devoted much attention with the object of preventing further accidents through the gas-container becoming flaccid. It was on this airship that he won the Deutsch prize, on the 19th of October, 1901. The voyage was an eventful one. On turning the Tower and facing home the wind was against the

aeronaut, and at this critical moment the motor began to work badly and threatened to stop. Santos-Dumont had to abandon the steering-wheel and attend to the engine. Then on reaching

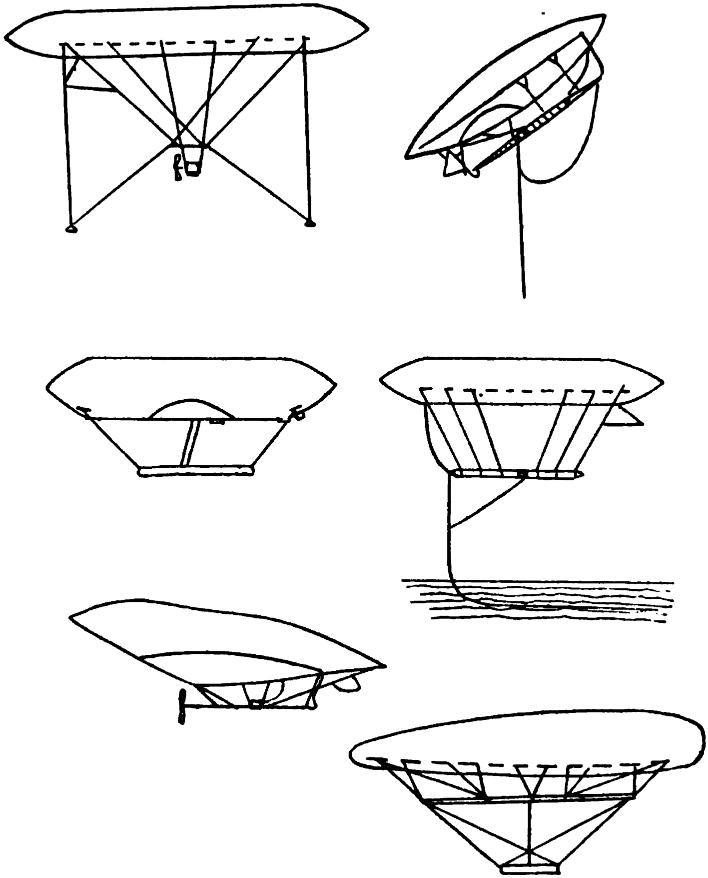


FIG. 11.—SANTOS-DUMONT'S AIRSHIPS.

Showing some of his principal designs and how they developed. The balloon at the bottom on the right is the most advanced type shown.

the Bois, by a phenomenon known to all aeronauts, the cool air from the trees caused the airship to descend. To correct this

tendency he had to throw back the shifting weights so that the airship pointed diagonally upwards. Then, suddenly, the motor started working at full speed again with the effect that the tilt of the balloon was increased before he had time to shift the weights back to the normal position. To the onlookers it appeared as if disaster was imminent. If he had not been racing against a time-limit he would, of course, have slowed the motor. Instead of doing so, he slowly righted himself by adjusting the weights.

Soon after winning the Deutsch prize the Brazilian Government presented him with a gold medal, on one side of which are the words: *Por ceos nunca d'antes navegados*—"Through heavens hereto unsailed."

Early in 1902 Santos-Dumont took his airship to Monte Carlo, and made a number of voyages over the Bay of Monaco and the open sea beyond. On the 14th of February he had an adventure. He ascended with the balloon only partially inflated, and as it had no great lifting power he had to keep it tilted upwards so that the action of the propeller made it ascend. In the shed the air had been cool, but under the influence of the hot sun the gas rapidly expanded, naturally crowding to the up-pointing stem. This increased the inclination of the balloon so that it struggled to point perpendicularly, and before the navigator could correct this dangerous tendency many of the wires gave way under the unusual pressure put upon them. In this position, too, some of the wires got in the way of the propeller. It was necessary to stop the motor, otherwise the balloon envelope would have been torn open. Having done that, Santos-Dumont found that he was being driven rapidly towards the houses of Monte Carlo. There was only one thing to do. Opening the valve, Santos-Dumont descended to the sea, and left the balloon and all its machinery to be recovered the next day and sent off to Paris for repairs. In all his later airships he divided the balloon into compartments by silk partitions, the material not being varnished.

By this means gas could slowly pass from one compartment to another to ensure equal pressure, yet the partitions were sufficiently good barricades to prevent any sudden rush of gas towards either extremity of the balloon.

In the summer of that year Santos-Dumont visited England and the United States. On his return to Paris he built his first regular airship station—really the first in the world—in Neuilly St. James. Here, by the spring of 1903, he had three airships—his No. VII., which was about twice the size of the No. VI.; his No. IX., a small "run-about" airship; and the No. X., the largest of all, which had a capacity of 80,000 cubic feet. In the No. IX. Santos-Dumont made some remarkable voyages. This was the smallest of possible dirigible balloons, having a capacity of only 7770 cubic feet, and giving the navigator a margin of only 66 lbs. of ballast. It was driven by a 3 h.p. Clement motor weighing 26½ lbs., and it proved capable of an independent speed of over 12 miles per hour. The gas-container was egg-shaped, the thick end being the front. Curiously enough, speaking of the speed of this vessel, Santos-Dumont expressed his opinion that this shape was little calculated for cutting the air. He was apparently surprised at obtaining such good speed. No doubt it was partly the shape of the balloon that enabled him to do so.

With this little airship Santos-Dumont made some very practical trips. He used to wander over the Bois and to and fro over the Seine, stopping sometimes at a café to take refreshments. On one occasion he travelled down the Avenue des Champs Elysees with his guide-rope trailing on the ground and the airship itself on a level with the third and fourth stories of the houses. He stopped at the door of his own house, No. 9, at the corner of the Rue Washington, on the 23rd of June, 1903, and got out and had luncheon.

During his guide-roping expeditions he surmounted obstacles by simply ascending a few feet. "So, some day," he writes, "will explorers guide-rope to the North Pole from their

ice-locked steamship." He went round the Arc de Triomphe one day, and remarked, "I might have guide-roped under it had I thought myself worthy."

Santos-Dumont, in his airship, descended close to a children's fête at Bagatelle on June 26, 1903, and asked the children if one of them would like to go up with him. He wrote: "Such were the confidence and courage of young France and America that instantly I had to choose among a dozen volunteers. I took the nearest to me. 'Are you not afraid?' I asked Clarkson Potter as the airship rose. 'Not a bit,' he answered. Let the name of Clarkson Potter be remembered. One day he will be an airship captain." Two or three days later a young Cuban lady, whose name is not given, made a voyage by herself in the Santos-Dumont No. IX.

The negotiations between the French Minister of War and Santos-Dumont and the airship manœuvres over the French army at the review on July 14, 1903, are matters of history. The French Minister of War was impressed with the possibilities of the airship, and soon afterwards Santos-Dumont offered to put his "aerial fleet" at the disposition of France in case of hostilities with any country except the two Americas. He wrote, explaining this: "It is in France that I have met with all my encouragement; in France and with French material I have made all my experiments. I excepted the two Americas because I am an American."

But the story of Santos-Dumont is not half finished. He was the pioneer in France of aviation, and his experiments, adventures, and escapes in that division of aeronautics must be given in another chapter.

CHAPTER XIV

SANTOS-DUMONT'S AEROPLANE ADVENTURES

THE remarkable Brazilian whose early aeronautical history in the period during which he devoted his attention to the dirigible balloon has already been told, demonstrated the alertness and studiousness of his character by being one of the first to believe in the possibilities of the heavier-than-air flying machine. On January 2, 1905, he announced his intention of competing for the Deutsch-Archdeacon prize. He had already built a machine in which he believed he could succeed, and this contrivance was a combination of vertical and horizontal screws.

The two upper propellers were to revolve in opposite directions in order to avoid what is known as "torque," or the bias given to the whole machine by the drag of a propeller turning in one direction. The car was made of bamboo, and it contained an 8-cylinder 28 h.p. Levavasseur (Antoinette) motor. This contrivance showed some capacity, and demonstrated that it was capable of lifting a considerable weight into the air; but that it was quite impracticable for human flying was very soon perceived by its inventor. The absence of the aeroplane principle made it exceedingly extravagant of motor power, besides involving a vertical and disastrous fall in the event of the motor stopping. Santos-Dumont, thereupon, built an aeroplane which was really an elaboration of the Hargrave, or "box" kite, with a motor. This new machine was called the "14 bis." It was exhibited to the French Aero Club on July 1906. The planes were of silk stretched over bamboo, and they had a total area of 237 square feet. The contrivance was smashed in one of its early trials, and Santos-Dumont immediately set to work to build an improved machine, with which he soon

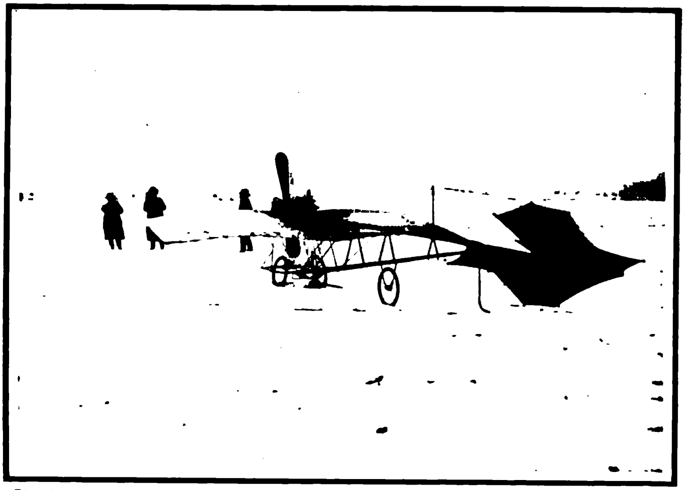
succeeded in flying a distance of 200 feet. It is worthy of remark that in his earliest trials with the flying machine Santos-Dumont was reluctant to dispense altogether with his old friend the airship, and he attached his new machine to an airship. This, however, proved to be a hindrance rather than a help. His first actual ascent into the air on a heavier-than-air machine was made with the aid of an inclined wooden frame, down which the machine ran until it gathered speed with its motor working sufficiently to give it lifting power.

Improvement followed improvement. The motor was changed for one of 50 h.p., and the two rear wheels of the under-carriage were discarded. On the 23rd of October Santos-Dumont won the Deutsch-Archdeacon Cup for a flight of not less than 25 metres. He actually flew much farther, but the officials of the French Aero Club became so excited when they saw that the machine was actually flying that they omitted to measure the distance accurately. In descending, the front wheels of the carriage of the machine were broken, a mishap that occurred through the pilot shutting off the engine while in the air and coming to the ground rather heavily.

A month later Santos-Dumont made a flight of 220 metres, his achievement being hailed in French aeronautical circles with tremendous enthusiasm, although the general public quite failed to grasp the significance of the feat and only credited the aviator with a few lucky long hops. At the time this was supposed to be the first ascent in a flying machine in Europe, the work of Ader not being recognised.

It is perfectly clear that Santos-Dumont worked independently and was in ignorance of the experiments of the Brothers Wright. Subsequently, as we shall see, he effected some striking improvements in his machine and made some fine flights, but his contributions were not so much to the science of dynamic flight as to the science of construction, to which he brought that extraordinary ingenuity and versatility for which he is famous.

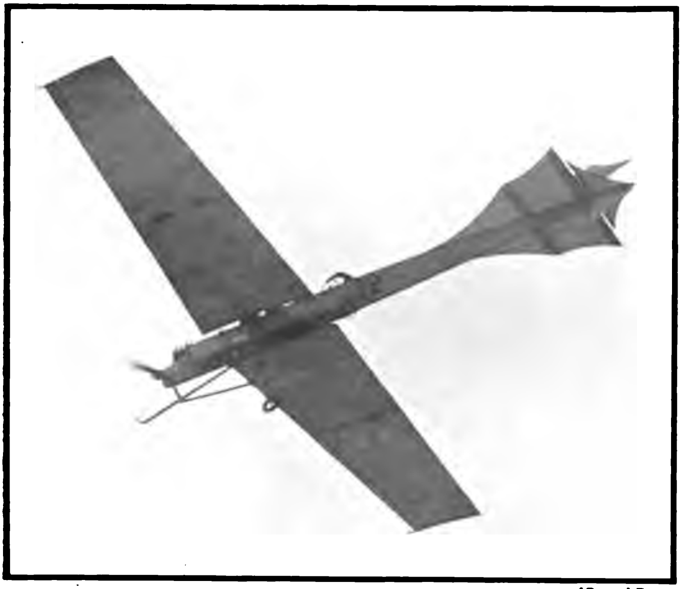
For some years he kept in the background, and men asked,



Photo] [*Boiak*

SANTOS DUMONT'S "DEMOISELLE"

The machine whose design the inventor gave freely to the world.



[*Record Press*

AN ANTOINETTE MONOPLANE

As it appears when flying overhead.

when Delagrange and Blériot and the Wrights sprang into fame, "What has become of Santos-Dumont? Has he given up flying" As a matter of fact, after much perseverance with the box-kite-like contrivance, he studied other possibilities, and early in 1909 he brought out his remarkable little monoplane. Having built this machine and flown with it he announced that he sought no inventor's rights, but that the designs of the machine were free to all the world to copy. The result, after

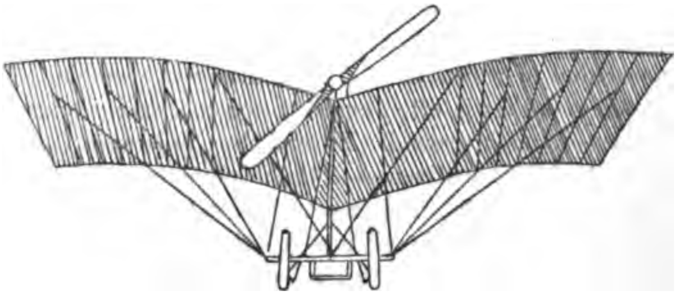


FIG. 12.—SANTOS-DUMONT'S AEROPLANE—THE "DEMOISELLE."

some little disputing on account of the question of certain rights attaching to the motor and certain agreements into which the inventor had entered, was that a large number of Santos-Dumont machines and slight variants on it were made in England and France. The original machine is described here:—Total area of sustaining surface, 115 square feet; span, 18 feet; total length, 20 feet. The machine was remarkable at the time for the low position occupied by the pilot, who sat completely underneath the main plane in a kind of cage formed by the plane above, and the various frame members and wire stays. The total weight of the machine, including the engine, was only 242 lbs. The tail was a most ingenious single member composed of a vertical plane intersecting a horizontal plane. The whole tail could be moved in any direction by simple movements of the control levers in the pilot's hand.

A great sensation was made by the appearance at the French Aeronautical Salon of 1908 of this toy-like machine

which differed in so many ways from other monoplanes. In flight its behaviour was so lively that it at once earned the name of "grasshopper." Santos-Dumont himself called it the "Demoiselle," or "dragon-fly."

Many were his tumbles on this machine, which soon showed great facility in falling completely over when running along the ground before an ascent or after landing. The driver on these occasions was to some extent protected by his cage, and very often he could prevent a fall by stopping the career of the machine with his hands on the running wheels, this being the only machine in which such a manœuvre was possible. The advantage was that it often enabled him to avoid running on to a piece of rough ground. Nevertheless, falls were frequent on account of the sensitiveness of the machine to puffs of air.

One of Santos-Dumont's most remarkable ascents was on January 3, 1910. While flying at a height of about 100 feet one of the wings of the machine collapsed and he began to fall earthwards. But the pilot, who, at that time, was one of the most seasoned aeronauts living, never for a moment lost his nerve. He even managed to control the fall, to some extent guiding the machine with the tail, and although it turned completely over twice he was not hurt beyond bruises and a few surface cuts.

The small cost of the "Demoiselle" and the fact that its design was freely copyable, gave it a certain popularity, and it was seen at numerous aviation meetings, where it performed very creditably, its pilots sharing with its inventor its propensity to falls, but enjoying, with him, immunity from severe hurt. At the Bournemouth meeting in 1910, Audemars smashed his Demoiselle three times. Indeed, it was necessary when travelling with the Demoiselle for the aviator to carry with him a small arsenal of spare wings and other parts. The machine came in for a good deal of derision; at the same time it was generally recognised by experts that it was likely to prove the prototype of the small one-man flying machine of the future.

CHAPTER XV

MECHANICS WHO HAVE BECOME FAMOUS

IF we look back to the eventful years 1907, 1908, 1909, and 1910, the period which saw dynamic flight demonstrated as practicable, we see a crowd of names leap from obscurity into fame. Very striking is the manner in which every great and forward step in scientific, mechanical, and economic progress has been the occasion for men of humble circumstances to make their mark on history. It is as if this were Nature's method of providing a levelling process, or as if it were the promotion ladder provided by the laws of evolution to keep replenished the aristocracy of genius and ability.

This book cannot, from its nature, be a complete history, chronologically ordered, so no attempt will be made in this chapter to refer to all the romances of the kind indicated in its title. A few of the more striking only will be given. Of these it is inevitable that France should provide the greatest number, for the peculiar genius of the French mechanic enabled him to perceive and to seize the great opportunities provided by the conquest of the air. In England, on the other hand, as a rule only gentlemen of leisure, in the period referred to, practised aviation.

The most remarkable instance, however, is provided by the American brothers, Wilbur and Orville Wright, who, in their early days, were bicycle makers and repairers, previously to which they printed a newspaper with home-made machinery constructed out of pieces of wood and string. But the story of the Wright Brothers is told in a separate chapter.

One of the first of a long list of humble men who became

famous was Hubert Le Blon, who performed that remarkable act of self-sacrifice narrated on page 118. Le Blon was in his youth a professional cyclist and motor driver. He drove in many famous automobile races in Europe and America, and, towards the end of 1907, he began to study aviation, and soon became associated with Léon Delagrange. He flew at the first English aviation meeting, that at Doncaster, in 1909. From the very first he experienced bad luck in flying, and had numerous narrow escapes. It was his intention only to work long enough to ensure the prosperity of his family, and then to retire. He had a conviction that he would meet with a fatal mishap, and only hoped that death might be sudden. Le Blon was a devout Catholic, and invariably attended Mass before a day's flying. In his day there were few aviators, so that every one of them was a famous man. Le Blon was one of the most skilful, and for a time he held a speed record. Although a mechanician he, like so many Frenchmen of his class, had all the manner and grace of the gentleman. He carried the courtesy of his country to a fine point, and, in spite of the adulation of the crowd, was extremely modest and unassuming. Not long before his death he was engaged by the British firm of Humbers to design and drive aeroplanes. At San Sebastian he twice fell into the sea, the first time being rescued with great difficulty; but on the second occasion, April 2, 1910, being pinned down by his machine, he was drowned before help could reach him.

Louis Paulhan was one of the finest examples of the class to which Le Blon belonged. He was apprenticed on the Messageries Maritimes Steamship line, and he was only twenty-seven years of age when he made the historic flight from London to Manchester, winning a prize of £10,000, thus achieving fame and almost affluence at one stroke. Paulhan owed his success to a positive genius for flying at a time when machines were far less efficient than they are to-day. But from his boyhood he had a strong predisposition to aeronautical

studies. He left the sea at the age of eighteen for the army, choosing voluntarily to join the aeronautical corps of the First Regiment of Engineers. In six months he became a sergeant, and at Chalais Meudon he saw a great deal of the experiments by Captain Ferber and Colonel Renard. Paulhan made many successful models, one of which, built in co-operation with his friend François Peyret, won the first prize in the French Aero Club's competition in 1905. He won prizes in subsequent years. After his period of army service he entered the Astra dirigible balloon factory as a mechanic, and worked a good deal on the Ville de Paris. He also assisted Kapferer in building an aeroplane, and he seems to have devoted his leisure to making model aeroplanes for sale. In the autumn of 1908 he won a Voisin biplane without a motor as first prize in a model competition. At that time he was earning not more than £3 a week and could not afford to buy a motor, so he formed a small company among his friends, and acquired one of the earliest of the Gnome motors, a wise and fortunate selection. Paulhan then began to teach himself to fly, and in a very few weeks showed that he possessed quite remarkable ability. He seemed to take as naturally to the air as does a bird. "When I'm on a long flight," he said once, "I smoke cigarettes, I laugh, I shout, I sing. It relieves the monotony and distracts one from thoughts of danger." There is no doubt that his close study of aeronautical theory and of models, and his experience with dirigible balloons, stood him in good stead when he turned to aviation. But he possessed also the infinite capacity for taking pains, which is, we are told, true genius. His rise to fame was rapid.

The makers of the Gnome motor supplied him with an engine, to be paid for out of his winnings, and it was not long before he won £2000 in prizes at one flying meeting, that held at Douai.

At the first great meeting at Rheims the big prize-winners were Farman, Curtiss, Latham, and Blériot; but although

Paulhan only won £400 at that meeting it was easy to see that he was destined to become one of the great flying men. This was shown in one way by his realising that in height lies safety, and the boldness with which he acted upon that belief at a time when men were only making their first timid excursions into the air. He held many records, and some of his flights were remarkable on account of the wind that he faced, and also because they were flights across country, the first really extensive journeys of the kind that were made. To his other qualities he added courage and extraordinary sang-froid. To some extent possibly he was indebted to a brief epoch in his early career when he performed in a travelling circus as a tight-rope walker. Like so many other successful aviators Paulhan settled down to designing aeroplanes, although he was too fond of flying for its own sake to give it up entirely. The President of the French Republic gave him the rank of Sub-Lieutenant of the Reserve, an unusual step to take.

That remarkable Russian aviator, Efimoff, to whom the sensation of fear was said to be unknown, was sent by a Company in Odessa to France to buy an aeroplane, learn to fly it, and return to Russia to give exhibitions. He arrived at Mourmelon, knowing nothing of the language, a huge, shy, and lonely man. He cycled to and from the aviation ground every morning and evening, and every midday for luncheon. He would stand in the workshops silently watching the mechanics at their work, and would watch flights with the closest possible attention. He took his turn with other pupils to go up as a passenger. His instructor told him by signs and occasional words what to do, and then Efimoff was allowed to control a machine himself. To every one's amazement he wasted no time running about on the ground, but after the very shortest run to gather speed, rose into the air. In that first flight he flew like a man of experience, describing circles, and descending perfectly. He was the hero of the day. Within the week he was flying across country, and within the month he was breaking records

for height, distance, and for exhibitions of the, at that time, uncommon spectacle of the vol-plané, descending with the engine shut off at the machine's natural gliding angle. The Russian Government appointed him at a salary of £2000 per annum as chief flight instructor to the Russian army.

Glenn H. Curtiss, the American whose own designed biplane, driven by his own designed motor, was one of the leading machines in 1909, 1910, and 1911, was a motorist and motor racer before he became an aviator. His experiments in association with Dr. Alexander Graham Bell, of Nova Scotia, and his work with Herring were of the utmost value. Another American who became famous as an aviator was S. F. Cody, who, however, in 1909 took out letters of naturalisation as a British subject. Cody's history was a most romantic one. He was early associated with circus shows and with horsemanship. Then he perfected a man-lifting kite with the necessary tackle, and obtained an appointment in connection with the British Army, for whom he manufactured military observation kites. He seems to have had remarkable gifts as a mechanician, and was appointed constructor in the balloon factory at Aldershot. The first British airship, known as the Nulli Secundus, was to a great extent Cody's work, and in its trial trips he drove the engine. On the biplane of his own design he made the longest cross-country flight up to the end of 1909, but he had many misfortunes and accidents, and it was only by reason of his determination to overcome all obstacles that he effected the progress which made his name one of the most considerable in the aeronautical world at that time. He was the first designer to carry into practice the idea of having two motors on an aeroplane.

To the same list of names belongs such men as Fernandez, a tailor, who made his own aeroplane and met his martyrdom in 1909; Bunau-Varilla, whose first flying machine was given to him when he was eighteen years old by his father as a reward for his success in an examination; Marcel Hanriot, who became

a famous professional aviator at the age of fourteen years on a monoplane designed by his father; Louis Wagner, also a pilot of the Hanriot monoplane, and who was formerly a racing motorist; Joseph Christiaens and Henri Rougier, two other famous aviators who began their career as motor drivers; Métrot, an Algerian railway engineer; John B. Moisant, a Chicago architect, the first aviator to fly from Paris to London; Roger Sommer, a felt manufacturer, whose hobbies, before he took up aviation, were cycling and motor cycling; Maurice Tétard and many others who became flight instructors; and the famous Farman Brothers. As to Sommer and the Farmans, other references to their life and work will be found in other chapters.

CHAPTER XVI

RESEARCH—ITS ROMANTIC SIDE

BESIDES the great leaders in aeronautical progress there are the lesser lights, who have all contributed their indispensable quota. Their names must not be allowed to become mere items in an index; and if we do not put them on the same level as the Wrights, Santos-Dumont, Zeppelin, and Blériot, we can, at any rate, preserve the records of their work and accept the inspiration of their example. Inevitably, men who spent many years studying and experimenting in this little-explored domain that for centuries had fascinated and lured the boldest and most imaginative of mankind, met strange adventures and surprises when the frontiers were at last crossed.

The belated recognition given to some of the early investigators such as Ader, Maxim, and Forest, who lived to see the triumph of ideas for which they had been ridiculed long before, was dealt with in Chapter VIII.; but the lives of inventors and aviators who took part in the exciting progress made during the first decade of this century teem with curious incident and adventure. To tell them all would take too long; and no matter how many can be crowded into the space of this chapter, the writer will be conscious of many omissions.

It will be well to give preference to those episodes which illustrate some definite step forward, or the discovery of some principle of aeronautical science. Take, for instance, the work of Robert Esnault-Pelterie, who, although he never became famous as an aviator, yet made experiments and contributions of the greatest importance to the science. The monoplane which he designed in 1908 took long to reach the first rank, but

the research upon which its design was based influenced to a very great extent the work of that period. Provoked by the rumours which reached Europe of wonderful achievements by the Brothers Wright, Esnault-Pelterie was induced to study for himself. He made a glider which resembled the Wright glider, in 1904, and with this contrivance he boldly practised in the neighbourhood of Calais. He hit on the happy idea of substituting for suitable winds for gliding the artificial draught produced by attaching his glider to a motor-car by a rope so that it should in effect form a kite. One little detail, however, did the experimenter forget, and that was to establish communication between himself in the air and the driver of the motor-car. On one occasion, through being unable to tell the driver what to do, he had a bad fall from a considerable height, smashing the machine to pieces but, by what seemed to be a miracle, without injury to himself. When he began to fly in his motor-driven aeroplane he had many narrow escapes. Twice he fell into a lake and was totally immersed for so long that it seemed as if he must be drowned.

It was Esnault-Pelterie who demonstrated that a piece of wire offers enormous resistance to the air, almost as much as a piece of wood as thick as a man's arm. It was this consideration that led him to prefer the monoplane type, because, he thought, it would be impossible to build a biplane without wires. Incidentally, it may be remarked, he considered that it is the vibration of wires that causes such tremendous air-resistance. His own monoplane was remarkable for its absence of bracing wires.

When Blériot flew across the Channel the attention of the world was riveted on his aeroplane. Its white wings and the story of their evolution appealed to the imagination of the chroniclers. It did not occur to most people that there was anything interesting in the motor. In the descriptions of the machine it was simply stated that the aeroplane was driven by an Anzani motor of three cylinders giving 25 h.p.,

and that was all. Yet the production of this motor, which achieved fame in that flight, was one of the most interesting episodes in the advance of aeronautical science. The inventor was quite a young man, and in boldly departing from the conventional types of petrol motor he demonstrated that he was a man of originality. He produced his earliest engines in a fashion far removed from the ordinary methods of the workshop. His capital was very limited, and he therefore employed a very small staff and made his engines one by one. The character of this inventor is shown by the fact that on more than one occasion, when the running of an engine has not pleased him, he has taken up a hammer and smashed it to pieces. But his perseverance and talent were rewarded, and he produced a machine which brought him fame and success and, what is equally important, was a definite contribution to the science suggesting points to other designers and so adding to the sum of human knowledge. The workmanship of these motors was superb. It is, by the way, curious how national characteristics are manifested in mechanical productions. Italian workmanship in the details of motors and various instruments is very remarkable for its beauty and for what engineers have described to me as its "feeling" and "something like intuition." And this is what one would have expected of a race of artists. At the same time, Italian work has a way of breaking off from conventionality and straying from scientific exactitude. The work of French mechanics is valuable on account of its fineness and precision.

If the records of the Patent Office could speak, what stories they would tell of devotion in the face of enormous difficulties, in spite of poverty and discouragement of all kinds, often in the pursuit of some wildly impossible idea, but sometimes in the effort to give to an unbelieving world some substantial gift. No division of patents contains more human interest than that which concerns aeronautics, and this is true not only of Great Britain but of France and Germany

and America. Sometimes, as in the case of Ader and Maxim, who form the subject of another chapter, recognition came eventually. This may be said also to be the case of Spiess, a native of Strasburg, a French citizen who is acknowledged now to have anticipated in his designs for airships the ideas which Zeppelin long afterwards put forward. Spiess designed a dirigible balloon just after the Franco-German war. His conception was not a merely fanciful one, a mere vague idea. He drew up a design which entered fully into every detail, giving all the measurements and quantities of the airship. It was to have a rigid frame of metal, and the gas-chamber was to be divided into a number of sections. The car was to be very near to the gas-container, the propellers in pairs on each side. One thing, of course, this design lacked, and that was the explosion motor, the invention of which occurred some years later. A model of the airship was shown at the Aeronautical Exhibition in Paris in 1909, and everybody was struck by its remarkable likeness to the Zeppelin in all essentials. For that matter, early last century Cayley clearly indicated the lines on which the modern dirigible balloon would be designed. He even suggested the application for driving power of a primitive kind of propeller like the familiar helicopter toy, which appears to have been in existence long before Cayley's time.

Even more striking is the fact that the first principles of the aeroplane were discovered and applied in Australia by Laurence Hargrave, of Sydney, in 1884. This was, of course, subsequent to Wenham's important researches in the lifting power of planes arranged in tiers one above the other, which were as long ago as 1866. But Hargrave was working on an entirely independent line, his experiments being with various forms of kites. When Wilbur Wright was a boy Hargrave demonstrated the superior efficiency of his cellular kite over the ordinary kite. Wilbur Wright, Chanute, Maxim, and Threlfall are among the great authorities who have

acknowledged the great debt of science to the Australian. There is no question that Hargrave's papers were used by these and other inquirers, and, as we all know, one of the very earliest successful biplanes, Santos-Dumont's, was essentially a box-kite contrivance driven by a motor. James Hargrave never reaped the reward to which the importance and value of his work should really have entitled him. Horatio Phillips,

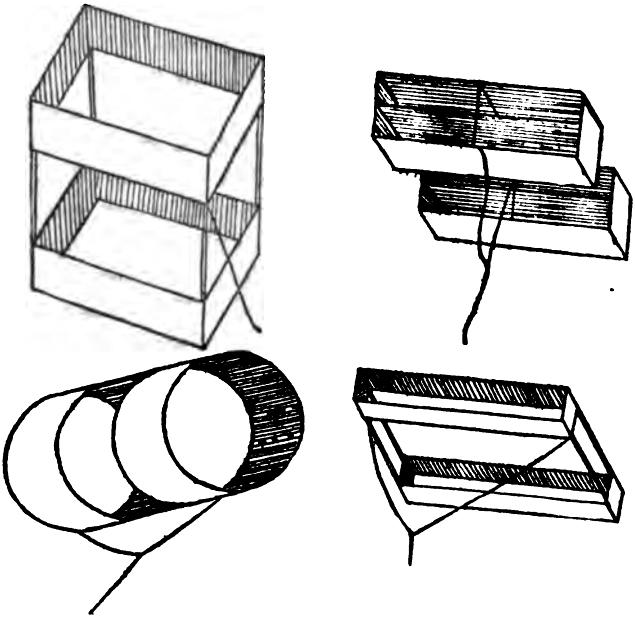


FIG. 13.—VARIOUS FORMS OF THE HARGRAVE KITE.

who made important investigations in the actions of curved surfaces in the air, was another neglected pioneer.

It may be said that every practical new experiment in aviation has been made at the risk of life. That is to say, so little was known definitely as to the capacity of machines and of the materials of which they were made, that the moment an experimenter tried any form of new contrivance he risked his life, no matter how carefully he worked out his theories on paper.

Only by proceeding very slowly step by step could the risk be reduced to reasonable limits. Those who understood the subject best proceeded with the greatest caution, and to them rather than to the impatient and the daring has progress been due. The story of Wilbur and Orville Wright, which will occupy the next chapter, illustrates this point. No change in their apparatus was ever made without great precautions. The death-roll of aviation has not been great when one considers the nature of the experiments that have been made. It would have been still smaller if several of those who have lost their lives had observed reasonable care. Some of the martyrs were engaged in trying the effect of new devices at the time of their death. One case of the kind is memorable. It is that of Léon Delagrange, who was trying a combination of aeroplane and motor that threw light on important questions. Putting a 50 h.p. Gnome motor to drive the Blériot XI. monoplane was a very risky thing to do, and this Delagrange fully realised. There was no data at the time as to the enduring quality of the structure of this or other aeroplanes. All that was known was that with the usual 25 h.p. motor the machine seemed quite strong enough. It was difficult to realise that by simply putting in a somewhat heavier motor, breaking point would be reached, even though in this case the motor was one of the revolving type. That there was some risk Delagrange realised, and his first flights on this machine were made with the engine working at low pressure. Then, as he found no bad results, he gradually increased the power. It was during these experiments that he discovered a remarkable phenomenon of which he told René Gasnier, who has since related the conversation. Delagrange said that he found when his machine was going at full speed he had the utmost difficulty in obtaining any effect at all by the use of his elevating plane. The machine was almost perfectly stable, and he could not descend to the ground without slowing the engine. On that Gasnier raised the question whether the Gnome motor had any gyroscopic effect. What is important at the moment is the fact

that this machine was subjected to more than normal pressure: not being able to give way before a side or front gust there would be a tendency to break. That was, indeed, accepted as the cause of the accident by which Delagrange was killed at Bordeaux on the 4th of January, 1910. There is no doubt, too, that the forepart of the fuselage was minus one or two of its members and was thus weakened.

Whether Delagrange realised the possibility of the motor's gyroscopic effect will never be known. All we know is that he observed that the machine was unusually steady in flight, and he proceeded with his experiments very cautiously, not attempting in the first trials to put on the engine's full power. It is remarkable that a few weeks later Hubert Le Blon, his pupil, met his death while flying an exactly similar machine. A few days before his death Le Blon told the present writer that he also had observed the steadying effect of the Gnome motor, but he did not believe that it acted as a gyroscope. It seems beyond dispute that both aeroplanes collapsed at the moment of making a turn, and this possibly bears out the gyroscope theory, since a gyroscope resists any tendency to turn out of the plane in which it is revolving. If we accept this theory we have yet to account for the resistance of the aeroplane, as testified by Delagrange and Le Blon, to the movements of the elevator. This, indeed, must have been due to the excessive speed at which this monoplane travelled when driven by the Gnome motor.

Naturally the great speed attained with the Blériot monoplane and Gnome motor was sufficient, in itself, to attract many imitators of Delagrange. Blériot himself flew in a machine of this kind.

On biplanes, which have a far greater lifting surface than the Blériot XI., the Gnome motor has no appreciable gyroscopic effect. It does not form so considerable a part of the weight, and it occupies a different position. Biplanes, moreover, permit of much greater structural strength than do mono-

planes. Questions of this nature were raised at the time of these two accidents.

In one sense it may be said that the accidents were necessary to the progress of aeronautical science, although to take that point of view seems rather to condone a blundering and merciless advance; but it must be admitted that they call attention in a way that perhaps nothing else could have to the vital question of the relation between the structural strength of machines and the power of the motors driving them, and especially they raised the question of the possible gyroscopic effect of the motor. It used to be thought that a propeller had a gyroscopic effect, and some of the famous inventors have referred to this as if it were an accepted fact. One reason for having two propellers in certain biplanes was that one of them revolving in the opposite direction to the other should neutralise its supposed gyroscopic effect. It is known, however, that any gyroscopic action there may be is so slight that it may be ignored. There is what is known as the "throw" of a propeller, but this is only felt when the machine is just starting along the ground, and it leaves off the moment the efficient thrust is being given by the propeller; in other words, as soon as the machine is going at its proper speed.

These are just a few examples of the dangers that have beset and still beset those who experiment with aerial machines, but the lives of some of the pioneers have been one long series of thrilling incidents and wonderful episodes.

CHAPTER XVII

WILBUR AND ORVILLE WRIGHT

THE work of Wilbur and Orville Wright was of epoch-making importance, although, as the reader will have been able to gather from the foregoing pages, the two famous brothers were neither the first to make a successful man-lifting glider nor the first to construct a motor-driven flying machine. What gives them their high position in the development of aeronautical science is the fact that they were the first to make mechanical flight really practicable, and to demonstrate the fact before the whole world. They established a successful type of aeroplane embodying many new principles, and although their theories were at once challenged by the school of flight which was springing up in France, it held its own. Moreover, their experiments enabled them to establish certain facts and data which were of tremendous importance to the science of flight.

I am enabled by the courtesy of Wilbur and Orville Wright to give the story of their work in their own words. Much of the material in this chapter is reprinted from papers read by Wilbur Wright before the Society of Western Engineers of Chicago on September 18, 1901, and on June 1, 1903. Other portions were indicated to me by the Wright Brothers personally. No doubt the work of other investigators would make an almost equally interesting narrative if described in the same detail. Take, for instance, the experiments of Ferber, Blériot, and Esnault-Pelterie, to which I have given far less space. But there is not room to give all these in detail, nor would it be necessary to do so. The work of the Wrights was

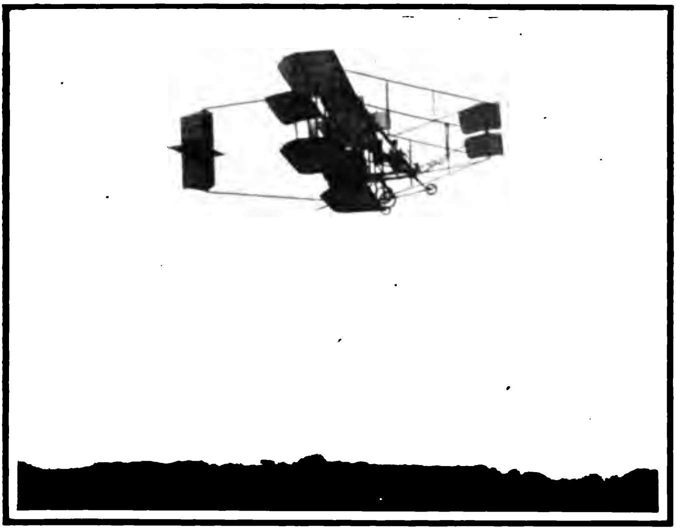
very much more important, and there is this advantage, that the student who studies it closely, especially in the full reports of Wilbur Wright's lectures, obtains a very sound basis of aeronautical science.

The interest of the two famous Americans in flying dated from the autumn of 1878. They describe how their father came into the house one evening with some object partly concealed in his hands, and before they could see what it was tossed it into the air. Instead of falling to the ground, as they expected, it flew across the room till it struck the ceiling, where it fluttered awhile, and finally sank to the floor. It was a little toy known to scientists as a "helicoptère," but which they, with sublime disregard for science, at once dubbed a "bat." It was a light frame of cork and bamboo, covered with paper, and forming two screws, driven in opposite directions by rubber bands. A toy so delicate lasted only a short time in the hands of small boys, but its memory was abiding.

In after years when endeavouring to make larger "helicoptères" they found that the larger the "bat" the less it flew. They had not then learned that every time they doubled the diameter of the screws the contrivance required eight times as much power.

They were enthusiastic kite-flyers also; but until they heard of the death of Lilienthal the subject of aerial navigation did not attract their mature and serious consideration. They then studied every work on the subject they could find, and it is interesting to record the fact that they have expressed their indebtedness to the writings of English authorities.

Describing this part of their progress they say that in the field of aviation they found that there were two schools. The first, represented by such men as Professor Langley and Sir Hiram Maxim, gave chief attention to power-flight; the second, represented by Lilienthal, Mouillard, and Chanute, to soaring flight. "Our sympathies were with the latter school, partly from impatience at the wasteful extravagance of mount-



[L. N. A. photo

THE CODY BIPLANE

Cody's romantic history and his struggles as an inventor are given on p. 159.

[L. N. A. photo

PLOUGHING THE AIR

A Hanriot monoplane flying over a farm at Weybridge.

ing delicate and costly machinery on wings which no one knew how to manage, and partly, no doubt, from the extraordinary charm and enthusiasm with which the apostles of soaring flight set forth the beauties of sailing through the air on fixed wings, deriving the motive-power from the wind itself."

The beginning of their own practical experiments is thus described by Wilbur Wright:—

"The difficulties which obstruct the pathway to success in flying-machine construction are of three general classes: (1) Those which relate to the construction of the sustaining wings; (2) those which relate to the generation and application of the power required to drive the machine through the air; (3) those relating to the balancing and steering of the machine after it is actually in flight. Of these difficulties, two are already to a certain extent solved. Men already know how to construct wings or aeroplanes, which, when driven through the air at sufficient speed, will not only sustain the weight of the wings themselves, but also that of the engine and the engineer as well. Men also know how to build engines and screws of sufficient lightness and power to drive these planes at sustaining speed. Inability to balance and steer still confronts students of the flying problem, although nearly ten years[1] have passed. When this one feature has been worked out, the age of flying machines will have arrived, for all other difficulties are of minor importance.

"The person who merely watches the flight of a bird gathers the impression that the bird has nothing to think of but the flapping of its wings. As a matter of fact, this is a very small part of its mental labour. Even to mention all the things the bird must constantly keep in mind in order to fly securely through the air would take a considerable time. If I take a piece of paper and, after placing it parallel with the ground, quickly let it fall, it will not settle steadily down as a staid, sensible piece of paper ought to do, but it insists on

[1] Since Lilienthal's success.

contravening every recognised rule of decorum, turning over and darting hither and thither in the most erratic manner, much after the style of an untrained horse. Yet this is the style of steed that men must learn to manage before flying can become an everyday sport. The bird has learned this art of equilibrium, and learnt it so thoroughly that its skill is not apparent to our sight. We only learn to appreciate it when we try to imitate it.

"Now there are only two ways of learning to ride a fractious horse: one is to get on him and learn by actual practice how each motion and trick may be best met; the other is to sit on a fence and watch the beast a while, and then retire to the house and at leisure figure out the best way of overcoming his jumps and kicks. The latter system is the safer, but the former, on the whole, turns out the larger proportion of good riders. It is very much the same in learning to ride a flying machine. If you are looking for perfect safety, you will do well to sit on a fence and watch the birds; but if you really wish to learn, you must mount a machine and become acquainted with its tricks by actual trial.

"The balancing of a gliding or flying machine is very simple in theory. It merely consists in causing the centre of pressure to coincide with the centre of gravity.

"In actual practice," continues Wilbur Wright, "there seems to be an almost boundless incompatibility of temper, which prevents their remaining peaceably together for a single instant, so that the operator, who in this case acts as a peacemaker, often suffers injury to himself while attempting to bring them together. If a wind strikes a vertical plane, the pressure on that part to one side of the centre will exactly balance that on the other side, and the part above the centre will balance that below. This point we call the centre of pressure. But if the plane be slightly inclined, the pressure on the part nearest the wind is increased and the pressure on the other part decreased, so that the centre of pressure is now

located, not in the centre of the surface, but a little towards the side which is in advance. If the plane be still farther inclined, the centre of pressure will move still farther forward. And, if the wind blow a little to one side, it will also move over as if to meet it. Now, since neither the wind nor the machine, for even an instant, maintains exactly the same direction and velocity, it is evident that the man who would trace the course of the centre of pressure must be very quick of mind; and he who would attempt to move his body to that spot at every change must be very active indeed. Yet that is what Lilienthal attempted to do, and did with most remarkable skill, as his two thousand glides sufficiently attest.

"It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. Lilienthal, in five years of time, had spent only five hours in actual gliding through the air. The wonder was not that he had done so little but that he had accomplished so much. It would not be considered at all safe for a bicycle rider to attempt to ride through a crowded city street after only five hours' practice spread out in bits of ten seconds each over a period of five years, yet Lilienthal with his brief practice was remarkably successful in meeting the fluctuations and eddies of wind-gusts. We thought that if some method could be found by which it would be possible to practice by the hour instead of by the second, there would be a hope of advancing the solution of a very difficult problem. It seemed feasible to do this by building a machine which would be sustained at a speed of 18 miles per hour, and then finding a locality where winds of this velocity were common. With these conditions, a rope attached to keep it from floating backwards would answer very nearly the same purpose as a propeller driven by a motor, and it would be possible to practice by the hour, and without any serious danger, as it would not be necessary to rise far from the ground, and the machine would not have any forward motion at all. We

found, according to the accepted tables of air-pressures on curved surfaces, that a machine spreading 200 square feet of wing-surface would be sufficient for our purpose, and that places could easily be found along the Atlantic coast where winds of 16 to 25 miles were not at all uncommon. When the winds were low it was our plan to glide from the tops of sand-hills, and when they were sufficiently strong to use a rope for our motor and fly over one spot.

"Our next work was to draw up the plans for a suitable machine. After much study we finally concluded that tails were a source of trouble rather than of assistance, and therefore we decided to dispense with them altogether. It seemed reasonable that, if the body of the operator could be placed in a horizontal position instead of the upright, as in the machines of Lilienthal, Pilcher, and Chanute, the wind resistance could be very materially reduced, since only one square foot instead of five would be exposed. As a full half horse-power could be saved by this change we arranged to try the horizontal position.

"The balancing of a flyer may seem, at first thought, to be a very simple matter, yet almost every experimenter had found in this the one point which he could not satisfactorily master. Many different methods were tried. Some experimenters placed the centre of gravity far below the wings, in the belief that the weight would naturally seek to remain at the lowest point. It was true that, like the pendulum, it tended to seek the lowest point, but also, like the pendulum, it tended to oscillate in a manner destructive of all stability. A more satisfactory system, especially for lateral balance, was that of arranging the wings in the shape of a broad V, to form a dihedral angle with the centre low and the wing-tips elevated. In theory this was an automatic system, but in practice it had two serious defects: first, it tended to keep the machine oscillating, and second, its usefulness was restricted to calm air.

"In a slightly modified form the same system was applied to the fore-and-aft balance. The main aeroplane was set at a

positive angle and a horizontal tail at a negative angle, while the centre of gravity was placed far forward. As in the case of lateral control, there was a tendency to constant undulation, and the very forces which caused a restoration of balance in calms caused a disturbance of the balance in winds. Notwithstanding the known limitations of this principle it had been embodied in almost every prominent flying machine which had been built.

"After considering the practical effect of the dihedral principle, we reached the conclusion that a flyer founded upon it might be of interest from a scientific point of view, but could be of no value in a practical way. We therefore resolved to try a fundamentally different principle. We would arrange the machine so that it would not tend to right itself. We would make it as inert as possible to the effects of change of direction or speed, and thus reduce the effects of wind-gusts to a minimum. We would do this in the fore-and-aft stability by giving the aeroplanes a peculiar shape; and in the lateral balance by arching the surfaces from tip to tip, just the reverse of what our predecessors had done.

"The method of control used by Lilienthal, which consisted in shifting the body, did not seem quite as quick or effective as the case required; so after long study we contrived a system consisting of two large surfaces on the Chanute double-deck plan, and a smaller surface placed a short distance in front of the main surfaces in such a position that the action of the wind upon it would counterbalance the effect of the travel of the centre of pressure on the main surfaces. Thus, changes in the direction and velocity of the wind would have little disturbing effect, and the operator would be required to attend only to the steering of the machine, which was to be effected by curving the forward surface up or down. The lateral equilibrium and the steering to right or left were to be attained by a peculiar torsion or bending of the main surfaces, which was equivalent to presenting one end of the wings at a greater angle than the other.

"With these plans we proceeded, in the summer of 1900, to Kitty Hawk, North Carolina, a little settlement located on the strip of land that separates Albemarle Sound from the Atlantic Ocean. Owing to the impossibility of obtaining suitable material for a 200-square-foot machine, we were compelled to make it only 165 square feet in area, which, according to the Lilienthal tables, would be supported at an angle of 3 degrees (from the horizontal) in a wind of about 21 miles per hour. On the very day that the machine was completed the wind blew from 25 to 30 miles per hour, and we took it out for trial as a kite. We found that while it was supported with a man on it

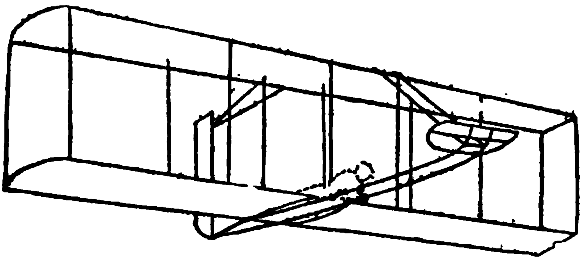


FIG. 14.—WRIGHT'S GLIDING APPARATUS.

in a wind of about 25 miles, its angle was much nearer 20 degrees than 3 degrees. Even in gusts of 30 miles the angle of incidence did not get as low as 3 degrees, although the wind at this speed has more than twice the lifting power of a 21-mile wind. As winds of 30 miles per hour are not plentiful on clear days it was at once evident that our plan of practising by the hour day after day would have to be postponed. Our system of twisting the surfaces to regulate the lateral balance was tried and found to be much more effective than shifting the operator's body. On subsequent days, when the wind was too light to support the machine with a man on it, we tested it as a kite, working the rudders by cords reaching to the ground. The results were very satisfactory, yet we were well aware that

this method of testing is never wholly convincing until the results are confirmed by actual gliding experience.

"We then turned our attention to making a series of actual measurements of the lift and drift of the machine under various loads. So far as we were aware this had never previously been done with any full-size machine. The results obtained were most astonishing, for it appeared that the total horizontal pull of the machine while sustaining a weight of 52 lbs. was only 8·5 lbs., which was less than had previously been estimated for head-resistance of the framing alone.

"No hill suitable for the purpose could be found near our camp at Kitty Hawk. This compelled us to take the machine to a point four miles south, where the Kill Devil sand-hill rises from the flat sand to a height of more than 100 feet. Its main slope is towards the north-east, and has an inclination of ten degrees. On the day of our arrival the wind blew about 25 miles an hour, and as we had had no experience at all in gliding we deemed it unsafe to attempt to leave the ground. But on the day following, the wind having subsided to 14 miles per hour, we made about a dozen glides. It had been the original intention that the operator should run with the machine to obtain initial velocity and assume the horizontal position only after the machine was in free flight. When it came time to land he was to resume the upright position and alight on his feet after the style of previous gliding experimenters. But, on actual trial, we found it much better to employ the help of two assistants in starting, which the peculiar form of our machine enabled us readily to do, and in landing we found that it was entirely practicable to land while still reclining in a horizontal position upon the machine. Although the landings were made while moving at speeds of more than 20 miles an hour, neither machine nor operator suffered any injury.

"The slope of the hill was 9·5 degrees, or a drop of one foot in six feet. We found that after attaining a speed of about 25 or 30 miles with reference to the wind, or 10 to 15 miles over

the ground, the machine not only glided parallel to the slope of the hill, but greatly increased its speed, thus indicating its ability to glide on a somewhat less angle than 9·5 degrees when we should feel it safe to rise higher from the surface. The control of the machine proved even better than we had dared to expect, responding quickly to the slightest motion of the rudder.

"With these glides our experiments for the year 1900 closed. Although the hours and hours of practice we had hoped to obtain finally dwindled down to about two minutes, we were very much pleased with the general results of the trip; for setting out,

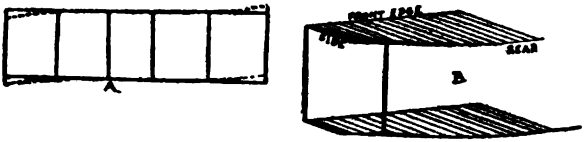


FIG. 15. A—BACK VIEW OF AEROPLANE WITH REAR CORNERS "WARPED." B—A CORNER VIEW.

as we did, with almost revolutionary theories on many points and an entirely untried form of machine, we considered it quite a point to be able to return without having our pet theories knocked on the head by the hard logic of experience, and our own brains dashed out in the bargain. Everything seemed to us to confirm the correctness of our original opinions—(1) that practice is the key to the secret of flying; (2) that it is practicable to assume the horizontal position; (3) that a smaller surface set at a negative angle in front of the main bearing surfaces or wings will largely counteract the effect of the fore-and-aft travel of the centre of pressure; (4) that steering up and down can be attained with a rudder without moving the position of the operator's body; (5) that twisting the wings so as to present their ends to the wind at different angles is a more prompt and efficient way of maintaining lateral equilibrium than shifting the body of the operator."

CHAPTER XVIII

WILBUR AND ORVILLE WRIGHT (*continued*)

WHEN the time came to design their new machine for 1901, Wilbur and Orville Wright decided to make it exactly like the previous machine in theory and method of operation. But as the former machine was not able to support the weight of the operator when flown as a kite, except in very high winds and at very large angles of incidence, they decided to increase its lifting power. Accordingly, the curvature of the surfaces was increased to one in twelve to conform to the shape on which Lilienthal's table was based, and, to be on the safe side, they decided also to increase the area of the machine from 165 square feet to 308 square feet, although so large a machine had never before been deemed controllable. The Lilienthal machine had an area of 151 square feet, that of Pilcher 165 square feet, and the Chanute double-decker 134 square feet. As the Wright system of control consisted in a manipulation of the surfaces themselves instead of shifting the operator's body, they hoped that the new machine would be controllable, notwithstanding its great size. According to their calculations it would obtain support in a wind of seventeen miles per hour with an angle of incidence of only three degrees.

They went into camp about the middle of July, and were soon joined by E. C. Huffaker, of Tennessee, an experienced aeronautical investigator in the employment of Chanute, by whom his services were lent, and by Dr. G. A. Spratt, of Pennsylvania, a young man who had made some valuable investigations of the properties of variously curved surfaces and the movements of the centre of pressure thereon. Early in August, Chanute went

down from Chicago to witness the experiments, and spent a week in camp with the Wrights.

The machine was completed and tried for the first time on July 27th in a wind blowing about thirteen miles an hour. The operator having taken a position near the supposed centre of pressure an attempt at gliding was made, but the machine turned downward and landed after going only a few yards. This indicated that the centre of gravity was too far in front of the centre of pressure. In the second attempt the operator took a position several inches further back, but the result was much the same. He kept moving further and further back with each trial, till finally he occupied a position nearly a foot behind that at which they had expected to find the centre of pressure. The machine then sailed off and made an undulating flight of a little more than 300 feet. To the onlookers this flight seemed very successful, but to the operator it was known that the full power of the horizontal rudder, or elevator, had been required to keep the machine from either running into the ground or rising so high as to lose all headway. In the 1900 machine one-fourth as much rudder action had been sufficient to give much better control. It was apparent that something was radically wrong, though they were for some time unable to locate the trouble. In one glide the machine rose higher and higher till it lost all headway. This was the position from which Lilienthal had always found difficulty in extricating himself, as his machine then, in spite of his greatest exertions, manifested a tendency to dive downward almost vertically and strike the ground head-on with frightful velocity. In this case a warning cry from the ground caused the operator to turn the elevator to its full extent and also to move his body slightly forward. The machine then settled slowly to the ground, maintaining its horizontal position almost perfectly, and landed without any injury at all.

"This was very encouraging," continues Wilbur Wright, "as it showed that one of the very greatest dangers in machines with horizontal tails had been overcome by the use of a front rudder.

Several glides later, the same experience was repeated with the same result. In the latter case the machine had even commenced to move backward, but was, nevertheless, brought safely to the ground in a horizontal position. On the whole this day's experiments were encouraging, for while the action of the rudder did not seem at all like that of our 1900 machine, yet we had escaped without difficulty from positions which had proved very dangerous to preceding experimenters, and, after less than one minute's practice, had made a glide of more than 300 feet, at an angle of descent of ten degrees, and with a machine nearly twice as large as had previously been considered safe.

"We had taken up aeronautics merely as a sport. We reluctantly entered upon the scientific side of it. But we soon found the work so fascinating that we were drawn into it deeper and deeper. Two testing-machines were built which we believed would avoid the errors to which the measurements of others had been subject.

"On resuming our gliding we found that the old conditions of the preceding year had returned, and, after a few trials, made a glide of 366 feet, and soon after, one of 389 feet. The machine with its new curvature never failed to respond promptly to even small movements of the horizontal rudder. The operator could cause it to almost skim the ground following the undulations of its surface, or he could cause it to sail out almost on a level with the starting-point, and, passing high above the foot of the hill, gradually settle down to the ground. The wind on this day was blowing 11 to 14 miles per hour. The next day, the conditions being favourable, the machine was again taken out for trial. This time the velocity of the wind was 18 to 22 miles per hour. At first we felt some doubt as to the safety of attempting free flight in so strong a wind with a machine of over 300 square feet and a practice of less than five minutes spent in actual flight. But after several preliminary experiments we decided to try a glide. The control of the machine seemed so good that we then felt no apprehension in sailing boldly forth. And, there-

after, we made glide after glide, sometimes following the ground closely and sometimes sailing high in the air. The highest wind thus experimented in was nearly twenty-seven miles per hour.

"After our return from Kitty Hawk we began a series of experiments to determine accurately the amount and direction of the pressure produced on curved surfaces when acted upon by winds at the various angles from zero to ninety degrees. These experiments are not yet concluded, but in general they support Lilienthal in the claim that the curves give pressures more favourable in amount and direction than planes, but we find marked differences in the exact values, especially at angles below ten degrees.

"We were unable to obtain direct measurements of the horizontal pressures of the machine with the operator on board, but by comparing the distance travelled in gliding with the vertical fall it was easily calculated that at a speed of twenty-four miles per hour the total horizontal resistances of our machine when bearing the operator amounted to 40 lbs., which is equivalent to about 2½ horse-power. It must not be supposed, however, that a motor developing this power would be sufficient to drive a man-bearing machine. The extra weight of the motor would require either a larger machine, higher speed, or a greater angle of incidence in order to support it, and, therefore, more power. It is probable, however, that an engine of 6 horse-power, weighing 100 lbs., would answer the purpose. Such an engine is entirely practicable. Indeed, working motors of one-half this weight per horse-power (9 lbs. per horse-power) have been constructed by several different builders.[1] Increasing the speed of our machine from twenty-four to about thirty-three miles per hour reduced the total horizontal pressure from 40 to about 35 lbs. This was quite an advantage in gliding, as it made it possible to sail about 15 per cent. further with a given drop. How-

[1] Wilbur Wright was speaking in 1901.

Topical Press

A Blériot Military Monoplane

Morane, the aviator, and two soldier passengers ready for a reconnaissance flight.

ever, it would be of little or no advantage in reducing the size of the motor in a power-driven machine, because the lessened thrust would be counterbalanced by the increased speed per minute. Some years ago Professor Langley called attention to the great economy of thrust which might be obtained by using very high speeds, and from this many were led to suppose that high speed was essential to success in a motor-driven machine. But the economy to which Professor Langley called attention was in foot-pounds per mile of travel, not in foot-pounds per minute. It is the foot-pounds per minute that fixes the size of the motor. The probability is that the first flying machines will have a relatively low speed, perhaps not much exceeding twenty miles per hour.

"There is another way of flying which requires no artificial motor, and many workers believe that success will first come by this road. I refer to the soaring flight by which the machine is permanently sustained in the air by the same means that are employed by soaring birds. They spread their wings to the wind and sail by the hour with no perceptible exertion beyond that required to balance and steer themselves. What sustains them is not definitely known, though it is almost certain that it is a rising current of air. But whether it be a rising current or something else, it is as well able to support a flying machine as a bird if man once learns the art of utilising it. In gliding experiments it has long been known that the rate of vertical descent is very much retarded and the duration of the flight greatly prolonged if a strong wind blows *up* the face of the hill parallel to its surface. Our machine when gliding in still air has a rate of vertical descent of nearly six feet per second, while in a wind blowing twenty-six miles per hour up a steep hill we made glides in which the rate of descent was less than two feet per second; and during the larger part of this time, while the machine remained exactly in the rising current, *there was no descent at all, but even a slight rise.* If the operator had had sufficient skill to keep himself from passing beyond the rising

current he would have been sustained indefinitely at a higher point than that from which he started. These slow glides in rising currents probably hold out greater hope of extensive practice than any other method within man's reach, but they have the disadvantage of requiring rather strong winds or very large supporting surfaces. However, when gliding operators have attained greater skill they can with comparative safety maintain

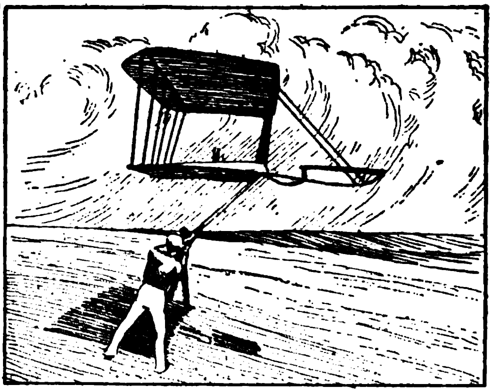


FIG. 16.—THE 1900 WRIGHT MACHINE SOARING IN A WIND OF THIRTY-FIVE MILES PER HOUR.

themselves in the air for hours at a time in this way, and thus by constant practice so increase their knowledge and skill that they can rise into the higher air and search out the currents which enable the soaring birds to transport themselves to any desired point by first rising in a circle and then sailing off at a descending angle. The illustration shows the machine alone flying in a wind of thirty-five miles per hour on the face of a steep hill 100 feet high. It will be seen that the machine not only pulls upward but also pulls forward in the direction from which the wind blows, thus overcoming both gravity and the speed of the wind. We tried the same experiment with a man on it, but found danger that the forward pull would become so

strong that the men holding the ropes would be dragged from their insecure foothold on the slope of the hill. So this form of experimenting was discontinued after four or five minutes' trial.

"The 1902 pattern was a double-deck machine having two surfaces, each 32 feet from tip to tip and 5 feet from front to rear. The total area of the main surfaces was about 305 square feet. The front rudder spread 15 square feet additional, and the vertical tail about 12 square feet, which was subsequently reduced to 6 square feet. The weight was 116½ lbs. Including the operator, the total weight was from 250 lbs. to 260 lbs. It was built to withstand hard usage, and, in nearly 1000 glides, was injured but once. It repeatedly withstood without damage the immense strains arising from landing at full speed in a slight hollow where only the tip of the wings touched the earth, the entire weight of machine and operator being suspended between.

"The practice ground at the Kill Devil hills consists of a level plain of bare sand from which rises a group of detached hills or mounds formed of sand heaped up by the winds. These hills are constantly changing in height and slope according to the direction and force of the prevailing winds. The three which we use for gliding experiments are known as the Big Hill, the Little Hill, and the West Hill, and have heights of 100 feet, 30 feet, and 60 feet respectively. In accordance with our custom of beginning operations with the greatest possible caution, we selected the Little Hill as the field of our first experiments, and began by flying the machine as a kite. The object of this was to determine whether or not it would be capable of soaring in a wind having an upward trend of a trifle over seven degrees, which was the slope of the hill up which the current was flowing.

"When I speak of soaring I mean not only that the weight of the machine is fully sustained, but also that the direction of the pressure upon the wings is such that the propelling and

retarding forces are exactly in balance; in other words, the resultant of all the pressures is exactly vertical and therefore without any unbalanced horizontal component. A kite is soaring when the string stands exactly vertical, this showing that there is no backward pull. The phenomenon is exhibited only when the kite is flown in a rising current of air. In principle, soaring is exactly equivalent to gliding, the practical difference being that in one case the wind moves with an upward trend against a motionless surface, while in the other the surface moves with a downward trend against motionless air. The reactions are identical. The soaring of birds consists in gliding downwards through a rising current of air which has a rate of ascent equal to the bird's relative rate of descent.

"Testing a gliding machine as a kite on a suitable slope with just enough wind to sustain the machine at its most favourable angle of incidence is one of the most satisfactory methods of determining its efficiency. In soaring, the kite must fly steadily with the string vertical or a little to the front. Merely darting up to this position for an instant is not soaring. On trial, we found that the machine would soar on the side of a hill having a slope of about seven degrees whenever the wind was of proper force to keep the angle of incidence between four and eight degrees. If the wind became too strong or too weak the ropes would incline to leeward.

"The kite experiments having shown that it ought to be possible to glide on the seven-degree slope, we next proceeded to try it. Although on this first day it was not considered advisable to venture upon any absolutely free flights, the machine soon demonstrated its ability to glide with this angle of descent. At a later period we made more than a hundred flights the full length of this slope, and landed a short distance out on the level ground. On the second day the machine was taken to the Big Hill, and regular gliding was commenced. The wind was somewhat brisk. In one flight the wind struck the machine from the left and began lifting the left wing in

a decidedly alarming manner. Owing to the fact that, in the new machine, changes had been made in the mechanisms operating the rudders, so that the movements were exactly reversed, it was necessary to think a moment before proceeding to make the proper adjustment. But meanwhile the left wing was rising higher and higher. I therefore decided to bring the machine to the ground as quickly as possible; but, in my confusion, forgot the change that had been made in the front rudder, and instinctively turned it the wrong way. Almost instantly it reared up as though bent on a mad attempt to pierce the heavens. But after a moment it seemed to perceive the folly of such an undertaking, and gradually slowed up till it came almost to a stop with the front of the machine still pointing heavenward. By this time I had recovered myself and reversed the rudder to its full extent, at the same time climbing upwards toward the front so as to bring my weight to bear on the part that was too high. Under this heroic treatment the machine turned downward, and soon began to gather headway again. By the time the ground was reached it was under fair control; but, as one wing touched first, it swung around in landing and came to rest with the wind blowing in from the rear. There was no unusual shock in landing, and no damage at all resulted.


FIG. 17.—THE 1902 WRIGHT MACHINE FLOWN AS A KITE IN A LIGHT WIND.

"In several other glides there were the disturbances of the lateral equilibrium more marked than we had been accustomed to experience with the former machines, and we were at a loss to know what the cause might be. The new machine had a

much greater tip-to-tip dimension than our former machines; it also had a vertical tail, while the earlier ones were tailless; and the wing-tips were on a line with the centre, while the old machines had the tips drawn down like a gull's wings. The trouble might be due to either of these differences. We decided to begin alterations at the wing-tips, and the next day made the necessary alterations in the trussing, thus bringing the tips six inches lower than the centre. For several days thereafter the weather was not suitable for gliding on account of rain, but finally the sky cleared and the machine was taken out again. As the anemometer indicated a wind velocity of more than eleven metres a second (twenty-four miles per hour), it was thought best to make use of the Little Hill in testing the effect of the changes that had been made. But later in the day, when the velocity fell to about nine metres a second, the Big Hill was tried again.

"On this day my brother Orville did most of the gliding. After a few preliminary flights to accustom himself to the new method of operating the front rudder, he felt himself ready to undertake the management of the lateral control also. Shortly afterwards he started on a flight with one wing slightly higher than the other. This caused the machine to veer to the left. He waited a moment to see whether it would right itself; but finding that it did not, decided to apply the control. At the very instant he did this, however, the right wing rose most unexpectedly much higher than before, and led him to think that possibly he had made a mistake. A moment of thought was required to assure himself that he had made the right motion and another to increase the movement. Meanwhile, he had neglected the front rudder (elevator) by which the fore-and-aft balance was maintained. The machine turned up in front more and more till it assumed a most dangerous attitude. We who were on the ground noticed this in advance of the aviator, who was thoroughly absorbed in the attempt to restore the lateral balance; but our shouts of alarm were drowned by

the howling of the wind. It was only when the machine came to a stop and started backward that he at length realised the true situation. From the height of thirty feet the machine sailed diagonally backward till it struck the ground. The unlucky aeronaut had time for one hasty glance behind him, and the next instant found himself the centre of a mass of fluttering wreckage. How he escaped injury I do not know, but afterwards he was unable to show a scratch or a bruise anywhere, though his clothes were torn. This little misadventure, which occurred almost at the very beginning of our practice with the new machine, was the only thing approaching an accident that happened during these experiments, and was the only occasion on which the machine suffered any injury. The latter was made as good as new by a few days' labour, and was not again broken in any of the hundred glides which we subsequently made with it."

CHAPTER XIX

WILBUR AND ORVILLE WRIGHT (*continued*)

"BY long practice the management of a flying machine should become as instinctive as the balancing movements a man unconsciously employs with every step in walking; but, in the early days, it is easy to make blunders," says Wilbur Wright. He and his brother made most of their glides quite close to the ground. Often a glide of several hundred feet would be made at a height of a few feet or even a few inches sometimes. Their aim was to avoid unnecessary risk.

Fully half of their glides were made in winds of over twenty miles an hour. On one occasion they found they had been gliding in a wind of thirty-seven miles an hour. Of course such high winds require much greater readiness on the part of the operator than the low winds, since everything happens much more quickly, but otherwise the difference is not so very marked. "In those machines which are controlled by the shifting of weight, the disturbing influences increase as the square of the velocity, while the controlling factor remains a constant quantity. For this reason, a limit to the wind velocity which it is possible to encounter safely with such machines is soon reached regardless of the skill of the operator."

Since soaring is merely gliding in a rising current, it would be easy to soar in front of any hill of suitable slope if a wind blew of sufficient force to furnish support provided the wind were steady. But, by reason of changes in wind velocity, there is more support at times than is needed, while at others there is too little, so that a considerable degree of skill, experience, and sound judgment are required to keep the machine exactly

in the rising current. So far their only attempts at soaring had been made on the Little Hill, which has a slope of only seven degrees. In a wind blowing from twenty-five to thirty-five miles per hour they frequently made glides of eight to fifteen seconds' duration with very little forward motion. Keeping within five or six feet of the ground, a momentary lessening of the wind-speed or a slight error in management was sufficient to bring about a landing in a short time.

"The wind had too little rising trend to make soaring easy. The buzzards themselves were baulked when they attempted to soar on this hill, as we observed more than once. It would be well within the power of the machine to soar on the Big Hill, which has steeper slopes, but we did not feel that our few hours of practice were sufficient to justify ambitious attempts too hastily. Before trying to rise to any dangerous height a man ought to know that, in an emergency, his mind and muscles will work by instinct rather than by conscious effort. There is no time to think.

"No complete record was kept of all the glides made. In the last six days of experiment we made more than 375, but these included our very best days. The total number for the season was probably between 700 and 1000. The longest glide was 622½ feet, and the time twenty-six seconds.

"On two occasions we observed a phenomenon whose nature we were not able to determine with certainty. One day my brother noticed in several glides a peculiar tapping as if some part of the machine were loose and flapping. Careful examination failed to disclose anything about the machine which could possibly cause it. Some weeks later, while I was making a glide, the same peculiar tapping began again in the midst of a wind-gust. It felt like little waves striking the bottom of a flat-bottomed row-boat. While I was wondering what the cause could be, the machine suddenly, but without any noticeable change in its inclination to the horizon, dropped a distance of nearly ten feet, and in the twinkling of an eye was flat on the

ground. I am certain that the gust went out with a downward trend, which struck the surfaces on the upper side. The descent was at first more rapid than that due to gravity, for my body apparently rose off the machine till only my hands and feet touched it. Toward the end the descent was slower. It may be that the tapping was caused by the wind rapidly striking the surfaces alternately on the upper and the lower sides. It is a rule almost universal that gusts come on with a rising trend and die out with a descending trend, but on these particular occasions there must have been a most unusual turmoil during the continuance of the gust which would have exhibited a very interesting spectacle had it been visible to the eye.

"Irregularities of the wind are most noticeable when the wind is high, on account of the greater power then exhibited, but light winds show almost equal relative variations. An aviator must expect to encounter in every flight variations in velocity, in direction, and in upward or downward trend. And these variations not only give rise to those disturbances of the equilibrium which result from the travel of the centre of pressure due to the changed angle of incidence, but also, by reason of the fact that the wind changes do not occur simultaneously or uniformly over the whole machine, give rise to a second series of disturbances of even more troublesome character. Thus, a gust coming on very suddenly will strike the front of the machine and throw it up before the back part is acted upon at all. Or the right wing may encounter a wind of very different velocity and trend from the left wing, and the machine will tend to turn over sideways. The problem of overcoming these disturbances by automatic means has engaged the attention of many very ingenious minds, but, to my brother and myself, it has seemed preferable to depend entirely on intelligent control. In all of our machines the maintenance of the equilibrium has been dependent on the skill and constant vigilance of the aviators.

"In addition to the work with the machine we also made many observations on the flight of soaring birds, which were

Photo] [*Bolak*

FLYING ROUND THE EIFFEL TOWER

A daring flight by the Comte de Lambert on a Wright biplane in the early days of aviation.

very abundant in the vicinity of our camp. Bald eagles, ospreys, hawks, and buzzards gave us daily exhibitions of their powers. The buzzards were the most numerous, and were the most persistent soarers. They apparently never flapped except when it was absolutely necessary, while the eagles and hawks usually soared only when they were at leisure. Two methods of soaring were employed. When the weather was cold and damp and the wind strong the buzzards would be seen soaring back and forth along the hills or at the edge of a clump of trees. They were evidently taking advantage of the current of air flowing upward over these obstructions. On such days they were often utterly unable to soar, except in these special places. But on warm, clear days when the wind was light they would be seen high in the air soaring in great circles. Usually, however, it seemed to be necessary to reach a height of several hundred feet by flapping before this style of soaring became possible. Frequently a great number of them would begin circling in one spot, rising together higher and higher till finally they would disperse, each gliding off in whatever direction it wished to go. At such times other buzzards only a short distance away found it necessary to flap frequently in order to maintain themselves. But when they reached a point beneath the circling flock they began to rise on motionless wings. This seemed to indicate that rising columns of air do not exist everywhere, but that the birds must find them. They evidently watch each other, and when one finds a rising current the others quickly make their way to it. One day, when scarce a breath of wind was stirring on the ground, we noticed two bald eagles sailing in circling sweeps at a height of probably 500 feet. After a time our attention was attracted to the flashing of some object considerably lower down. Examination with a field-glass proved it to be a feather which one of the birds had evidently cast. As it seemed apparent that it would come to earth only a short distance away, some of our party started to get it. But in a little while it was noticed that the feather was no longer falling, but, on the

contrary, was rising rapidly. It finally went out of sight upward. It apparently was drawn into the same rising current in which the eagles were soaring, and was carried up like the birds.

"The days when the wind blew horizontally gave us the most satisfactory observations, as then the birds were compelled to make use of the currents flowing up the sides of the hills, and it was possible for us to measure the velocity and trend of the wind in which the soaring was performed. One day four buzzards began soaring on the north-east slope of the Big Hill at a height of only ten or twelve feet from the surface. We took a position to windward and about 1200 feet distant. The clinometer showed that they were 4½ to 5½ degrees above our horizon. We could see them distinctly with a field-glass. When facing us the under side of their wings made a broad band on the sky, but when, in circling, they faced from us we could no longer see the under side of their wings. Though the wings then made little more than a line on the sky, the glass showed clearly that it was not the under side that we saw. It was evident that the buzzards were soaring with their wings constantly inclined about five degrees above the horizon. They were attempting to gain sufficient altitude to enable them to glide to the ocean beach three-fourths of a mile distant, but after reaching a height of about 75 feet above the top of the hill, they seemed to be unable to rise higher, though they tried a long time. At last they started to glide towards the ocean, but were compelled to begin flapping almost immediately. We at once measured the slope and the wind. The former was 12½ degrees; the latter was six to eight metres per second (about fifteen miles per hour). Since the wings were inclined five degrees above the horizon and the wind had a rising trend of fully 12 degrees, the angle of incidence was about 17 degrees. The wind did not average more than seven metres—fifteen miles an hour. For the most part the birds faced the wind steadily, but in the hills they were compelled to circle or glide back and forth in order to obtain speed sufficient to provide support. As the buzzard weighs about 8 lbs. per

square foot of wing area, the lifting power of the wind at 17 degrees angle of incidence was apparently as great as it would have been had it been blowing straight upward with equal velocity. The pressure was inclined five degrees in front of the normal, and the angle of the descent was 12½ degrees.

"On another day I stood on top of the West Hill, directly behind a buzzard which was soaring on the steep southern slope. It was just on a level with my eye and not more than 75 feet distant. For some time it remained almost motionless. Although the wings were inclined about five degrees above the horizon it was not driven backward by the wind. This bird is specially adapted to soaring at large angles of incidence in strongly rising currents. Its wings are deeply curved. Unless the upward trend amounts to at least eight degrees it seems to be unable to maintain itself. One day we watched a flock attempting to soar on the west slope of the Big Hill, which has a descent of nearly nine degrees. The birds would start near the top and glide down along the slope very much as we did with the machine, but we noticed that whenever they glided parallel with the slope their speed diminished, and when their speed was maintained the angle of descent was greater than that of the hill. In every case they found it necessary to flap before they had gone 200 feet. They tried time and again, but always with the same results. Finally, they resorted to hard flapping until a height of about 150 feet above the top of the hill was reached, after which they were able to soar in circles without difficulty.

"On another day they finally succeeded in rising on almost the same slope, from which it was concluded that the buzzards' best angle of descent could not be far from eight degrees. There is no question in my mind that men can build wings having as little as or less relative resistance than that of the best soaring birds.

"The bird's wings are undoubtedly very well designed indeed, but it is not any extraordinary efficiency that strikes with astonishment, but rather the marvellous skill with which they are

used. It is true that I have seen birds perform soaring feats of almost incredible nature in positions where it was not possible to measure the speed and trend of the wind, but whenever it was possible to determine by actual measurement the conditions under which the soaring was performed it was easy to account for it on the basis of the results obtained with artificial wings. The soaring problem is apparently not so much one of better wings as of better operators.

"The first flights with the power-machine were made on the 17th of December 1903. Although a general invitation had been extended to the people living within five or six miles, only five were willing to face the rigours of a cold December wind to see, as they no doubt thought, another flying machine *not* fly. The first flight lasted only twelve seconds. The fourth lasted fifty-nine seconds.

"In the spring of 1904 experiments were continued on Huffman Prairie at Simms Station, eight miles east of Dayton. The new machine was heavier and stronger, but similar to the one flown at Kill Devil hill. When it was ready for its first trial every newspaper in Dayton was notified, and about a dozen representatives of the Press were present. Our only request was that no pictures be taken and that the reports be unsensational so as not to attract crowds to our experiment-grounds. There were probably fifty persons altogether on the ground. When preparations had been completed a wind of only three or four miles was blowing—insufficient for starting on so short a track—but since many had come a long way to see the machine in action, an attempt was made. To add to the other difficulty the engine refused to work properly. The machine after running the length of the track slid off the end without rising into the air at all. Several of the newspaper men returned the next day, but were again disappointed. The engine performed badly, and after a glide of only sixty feet the machine came to the ground. Further trial was postponed until the motor could be put in better running condition.

"We had not been flying long in 1904 before we found that the problem of equilibrium had not as yet been entirely solved. Sometimes in making a circle the machine would turn over sideways despite anything the operator could do, although under the same conditions in ordinary straight flight it could have been righted in an instant. In one flight, in 1905, while circling round a honey locust-tree at a height of about fifty feet, the machine suddenly began to turn up on one wing and took a course toward the tree. The operator, not relishing the idea of landing in a thorn-tree, attempted to reach the ground. The left wing, however, struck the tree at a height of ten or twelve feet from the ground, and carried away several branches; but the flight, which had already covered a distance of six miles, was continued to the starting-point.

"The causes of these troubles—too technical for explanation here—were not entirely overcome till the end of September 1905. The flights then rapidly increased in length, till experiments were discontinued after the 5th of October, on account of the number of people attracted to the field. Although made on a ground open on every side and bordered on two sides by much-travelled thoroughfares, with electric cars passing every hour, and seen by all the people living in the neighhood for miles around, and by several hundred others, yet these flights have been made by some newspapers the subject of a great mystery."

At the time scarcely anybody attached any credence to the stories of the flying experiments at Kitty Hawk. They were not, as a matter of fact, studiously kept as a secret by the Wright Brothers. Many people witnessed them. But in Europe they were regarded as newspaper sensationalism, and Bennet Burleigh, the war correspondent, who witnessed some of them and wrote an account of them in the *Daily Telegraph*, found that the general public were not prepared to welcome the conquest of the air.

It is not necessary to detail here the later career of the

two brothers. They found that their own countrymen were unsympathetic. All the experiments had been conducted at their own expense, and attempts to secure the aid of rich Americans failed. In France, however, they met with enthusiasm. Their success on European soil in the summer of 1908 was at once acknowledged by the characteristically warm-hearted and imaginative French; and coming, as it did, at the time when Frenchmen were giving particular attention to the same problem it found an enlightened public opinion. The French were ready to acknowledge that the American school of flight was superior as regards achievement, but they were quick to oppose their own theories to it. For instance, the French aviators would have nothing to do with the tailless principle. They demanded automatic stability, and this they sought to obtain in the earlier machines, not only by means of a large tail, but also with the aid of vertical plane surfaces dividing two main planes into boxlike compartments. All this was before the triumphant monoplane had made its appearance.

It was on August 8, 1908, that Wilbur Wright made his first flight in Europe, and on various occasions he flew at Houandières, Auvours, Pau, Chalons, Le Mans, Berlin, and elsewhere. His first flight in France was almost exactly two years after Santos-Dumont's first aeroplane ascent. In the autumn of 1908 Wilbur Wright took up various passengers, among the first being Charles Stewart Rolls, who soon afterwards became a pupil. Rolls was the first English martyr to the motor-driven aeroplane, being killed at Bournemouth on July 12, 1910, soon after making the double crossing of the English Channel on his Wright machine.

It was while Wilbur Wright was making his early flights in France that his brother Orville, and Lieutenant Selfridge, of the United States army, had a terrible accident at Fort Meyer, when the latter was killed and the former severely injured. The accident was due to the transmission gear of the motor breaking.

Among the many distinguished people Wilbur Wright took up into the air was the German Crown Prince, on October 3, 1909. The two brothers received the gold medal of the Aeronautical Society of Great Britain in the same year.

Orville Wright achieved a flight of over an hour's duration as long ago as September 9, 1908, and on September 12th he stayed up for one hour and fourteen minutes. These feats created a tremendous impression at the time and did much to destroy the callousness and indifference which prevailed, especially in this country. On December 31st of that memorable year Wilbur Wright made a flight of two hours and nineteen minutes. He also demonstrated that his pupils could become adept after spending a few hours in the air, and his pupils in their turn became teachers.

One little incident revealed the real partnership which existed between the two brothers. The Wrights won the Michelin prize of £800 in 1908, and at the presentation Wilbur, having expressed his thanks, calmly divided the notes into two packets, and without a word handed one of them to Orville, while he put the other into his pocket.

The devotion of the two American experimenters to their work was shown in their manner of living. In 1910 they were still living with their father and sister in the wooden house they had grown up in from the time when they were all children. The workshop where they make their engines was within a quarter of a mile, and was the same where, six years before, they were turning out Wright bicycles. Even closer to the house was the little printing-works, where, before making bicycles, they expended their unlimited energy and ingenuity, not only in printing a newspaper, but in making the printing-machine, which they constructed out of pieces of wood and bits of string. This Robinson Crusoe printing-press was only designed for home use. At Le Mans, Wilbur Wright lived in his aeroplane shed, and was thereby enabled to keep guard over his treasures.

CHAPTER XX

THE DAWN OF A NEW ERA—1901 TO 1907

ON the 31st of December 1900—the eve of a new century —many were the speculations as to the future progress of mankind. Exhaustive histories of the nineteenth century dealing with every department of human activity were published in the newspapers, and eminent men were asked to forecast probable developments in the twentieth century. In the reviews of the past nothing could be said regarding achievements in aerial navigation. But in a few of the forecasts of the future the possibility of human flight was dimly foreshadowed. The boldest speculator, however, hazarded no guess as to date: one gathered that dynamic flight might be achieved somewhere towards the end of what was universally admitted to promise to be the most tremendous century in the world's history. Unknown to the generality of mankind, and ignored even by those who study scientific progress, a few men were at work upon aeronautical problems. It is instructive to refer to the records of aeronautical patents taken out at this period in Great Britain. In the last year of the nineteenth century there were twenty-three, and of these, three concerned ordinary balloons. In the following year there were thirty patents; in 1902 there were thirty; in 1903 there were twenty-eight; in 1904 there were forty-one; in 1905 there were nineteen; in 1906 there were forty-three; in 1907 there were eighty-two; and in 1908 there were one hundred and forty-five. These figures are eloquent of the sudden forward movement made possible by the invention and rapid development of the light internal combustion engine.

The only name that has survived of those who took out patents in the first year of the century is that of S. F. Cody.

The next year's list contains the famous aeronautical name of A. C. Spencer. In 1903 the names of Lebaudy, Maxim, Bartor, Baden-Powell, and Brennan appear. The list for 1904 contains the names of Maxim, Barton, and the Brothers Wright. It is not necessary at this moment to describe the inventions to which these patents refer. The work of the Brothers Wright is described by themselves in another portion of this book. And it must not be imagined for a moment that all the names famous

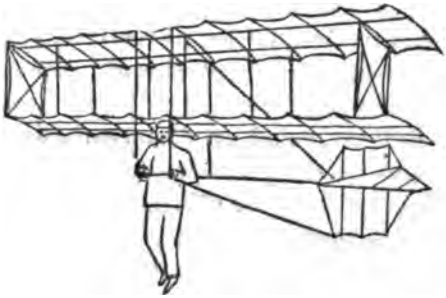


FIG. 18.—CHANUTE GLIDING.

Chanute sought to make equilibrium inherent in the machine by having the surfaces movable. He made over 700 glides with the apparatus.

as those of pioneers in aeronautical research are represented in the archives of the Patent Office.

When the new century dawned Captain F. Ferber, of the French army, was experimenting with gliding machines near Nice, and afterwards at Beuil and at Le Conquet. He was in communication with Chanute, and he made double-surface machines after having made many flights with monoplane gliders. His biplanes were to some extent inspired by the work of the Brothers Wright.

Captain Ferber's experiments were of great importance to the young science of dynamic flight. His book, *Aviation: its Dawn and its Development*, remains one of the most valuable works in the aeronautical student's bookcase. He invented a contrivance by which his trial aeroplanes, when he first

attached a motor, were suspended from a long arm, and it was not until 1905 that he attempted actual flight off the ground. Captain Ferber claimed that his machine possessed a very large measure of natural lateral stability. In 1905 he was attached to the aeronautical establishment of the French War Department at Chalais Meudon. He went to America to study the Wright machine on the spot. The story of Ferber's death is told in the chapter on the martyrs to mechanical flight.

While Ferber was conducting his experiments, Ernest Archdeacon, another Frenchman, who, however, had a good deal of Irish blood in his veins, was hard at work. Knowledge of the Wright Brothers' experiments had come to his ears, and found fruitful soil in his lively, enlightened, and enthusiastic mind. He threw himself into the study and patronage of aeronautical experiments with great zest. In 1903 he inaugurated a fund for experiments, and he built a machine of his own which was tried in April 1904 at Berck-sur-Mer, some successful glides being made. Owing to Archdeacon's energy an exhibition of gliding and flying machines was held in Paris in February 1905—not the first flying-machine exhibition in the world, for that was held in London by the Aeronautical Society many years before. The exhibition in Paris was, however, the first in which definite promise of the solution of the problem of aerial navigation was to be seen. Archdeacon experimented with a gliding machine towed by a motor-car in order to give the air-pressure necessary to lift it; in other words, an elaboration of the kite. His next gliding machine, which was like a huge box-kite, was tested over water towed by a fast motor-boat. It was operated by one of the Brothers Voisin and behaved very satisfactorily, although on one occasion Gabriel Voisin had an involuntary bath in the Seine.

Not only did Archdeacon himself conduct experiments, but he gave money for the encouragement of others. He presented the cup won by Santos-Dumont for a straight flight of 200 metres, and, with Henri Deutsch, gave the £2000 for the first flight in a closed circuit of a mile won by Henry Farman.

Underwood

WATCHERS ON THE FRONTIER

Spanish soldiers looking up at Garros, the aviator, on a flight from Paris to Madrid.

Gabriel Voisin, who was associated with Archdeacon, left him in 1905, and soon after founded the manufacturing firm of Voisin Brothers, the designers of the famous cellular type of biplane.

About this time we first make the acquaintance of Louis Blériot, who, while Archdeacon and Voisin were conducting gliding experiments on the Seine, had a similar contrivance to theirs near the same spot. It is sometimes forgotten that Blériot when he first studied aeronautics was associated with the Voisins, and was, moreover, an advocate of the biplane in preference to the monoplane, in the development of which he later

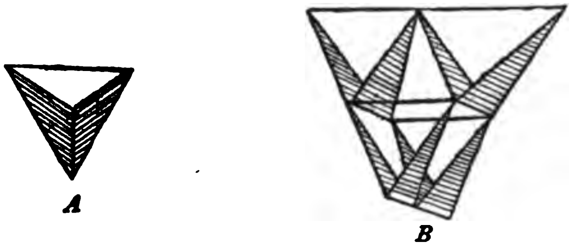


FIG. 19.—BELL'S TETRAHEDRAL KITE-CELL.

A is a unit cell; *B*, four joined. More than 3000 of these cells have been flown as one kite.

on achieved great fame. As this and the next few chapters deal with events in approximately chronological order, Blériot's achievements will be referred to in more than one place. It is important now to endeavour to realise that at the period with which we are dealing, namely 1904–1905, there were in France a number of keen scientific investigators studying these problems. One of these was Esnault-Pelterie, who sought to verify the results and conclusions attained by the Wright Brothers; and he demonstrated for himself that it was possible to glide at a smaller angle than one of nine degrees.

In America, meanwhile, there were others than Wilbur and Orville Wright slowly building up the first storey of the edifice of this fascinating science. One of the most famous was Dr. Alexander Graham Bell, famous also for his association

with Edison in other departments of scientific progress. In 1907 he constructed a man-carrying tetrahedral kite, composed of 3393 cells covered with silk, which rose from the water when attached to a tow-line of a motor-boat. One of the first to ascend in this remarkable kite was Lieutenant Selfridge, who was subsequently killed in an accident with a Wright machine. Later on Bell attached a motor to a contrivance of the same type, the motor being made by Glenn Curtiss, another famous name in aeronautics. With F. W. Baldwin, a Canadian engineer, and J. A. D. McCurdy, Bell formed the Aerial Experiment Association and built a number of motor-driven aeroplanes, some famous ones being called the "Red Wing," the "White Wing," and the "June Bug."

On this side of the Atlantic the work of J. J. Montgomery, a professor in Santa Clara College, California, is too often overlooked. He built a gliding machine resembling Langley's in outward appearance, but with movable parts which enabled it to be steered when descending. Moedebeck, in his *Pocket-Book of Aeronautics*, gives the following account of Montgomery's work: "He found a parachute jumper, J. M. Maloney, who was daring enough to attempt the unprecedented feat of gliding down with this apparatus from a height of 1000 metres or more." The apparatus consisted of two rectangular wings placed in tandem, each 24 feet across and 5 feet wide. The rear wing was so fastened to the fuselage as to be capable of motion in various directions controlled by the pilot. After a number of private tests, during which it was found that in descending from a height of 3000 feet the machine took thirteen minutes, it was publicly tested at Santa Clara on the 29th of April 1905. The operator Maloney cut adrift from his balloon at the height of nearly 4000 feet. During his descent he caused it to sweep in circles in order to demonstrate that he had it in full control, and he succeeded in alighting in a field previously specified about a mile from the starting-point.

In an article on his work contributed by Montgomery to

Aeronautics, he makes the following remarks: "During my work I had a few carping critics that I silenced by this standing offer. If they would deposit 1000 dollars I would cover it on this proposition. I would fasten a 150 lb. sack of sand in the rider's seat, make the necessary adjustments, and send up an aeroplane upside down with a balloon, the aeroplane to be liberated by a time-fuse. If the aeroplane did not immediately right itself, make a flight, and come safely to the ground, the money was theirs."

Maloney and another of Montgomery's pilots, Wilkie, actually made complete somersaults during descents, alighting safely. But on the 18th of July 1905, Maloney was killed under extraordinary circumstances. In cutting loose from the balloon something went amiss with the glider, the rear wings flapping loosely. The machine turned on its back and descended a little faster than a parachute. According to Moedebeck, who apparently obtained his information from the journals of the time, Maloney was killed by the fall. This, however, was not the case. It is true that Maloney only lived thirty minutes after the descent, but he was not injured by concussion with the earth. The only mark on his body was a small scratch from a wire. As a matter of fact, Maloney died from heart failure.

British students of aeronautics should not fail to study Montgomery's work, which they will find fully described in Lougheed's book and in other works. There is no doubt that he established patents covering the combination of flexible wing tips with curved wings, and his champions have even claimed that the Wright Brothers have infringed the Montgomery patents. His researches in aero-dynamics are very important. As long ago as 1883 he built a flapping-wing machine, and in 1884–85 he built small gliders with curved surfaces like the sea-gull's wings. One of these gliders had its wings set at a dihedral angle like the "Antoinette" monoplane.

In 1907 Henry Farman, a motor-car racer, and, like his brothers Richard and Maurice, in the automobile business, became interested in Archdeacon's work and in the experiments

of the Wright Brothers and Maxim. Years before he had heard of Lilienthal, Chanute, and Langley, and now he became convinced that dynamic flight was possible. Lack of means prevented immediate experiments except with models, from which, he says, he learned much. He practised gliding on the sand-hills of La Touquet, and in January 1907 he decided to build an apparatus propelled by a motor, and entrusted the Voisin Brothers with the work of constructing an ordinary cellular biplane, determining to modify it according to his own ideas. He received his machine in September of that year, and practised with it at Issy. We shall deal with his work in the next chapter, but here it is well to point out that Henry Farman is an Englishman. Any doubt of his nationality is disposed of by the following announcement in the *London Gazette* in September 1909:—

"The King has been pleased to give and grant unto Henry Farman, Esquire, His Majesty's royal licence and authority to accept and wear the Cross of Chevalier of the Legion of Honour conferred upon him by the President of the French Republic in recognition of valuable services rendered by him."

As to his own preference in the matter, it is shown in the following letter which he wrote to a French lady in reply to her question:—

"DEAR MADAM,—I am convinced that you would esteem me less should I deny the origin of my family, but having been brought up in France and having studied there, my heart is truly French.

"If I have succeeded in drawing a little of the world's attention upon myself, it is in France that my efforts have been crowned with success. I consider myself a Frenchman in every acceptation of the word.

"Moreover, at the time of the international Gordon-Bennett cup contest, England refused to be represented by me on the ground that I was more French than English.

"(Signed) H. FARMAN."

Date.	Pilot.	Place.	Time.	Distance.	Machine.
			Min. Sec.	Miles. Yds.	
1897.					
Oct. 14	Ader	Satory	...	0 325	Monoplane
1903.					
Dec. 19	*Wright Bros.	Dayton	...	0 248	Biplane
1905.					
Sept. 28	* ,, ,,	,,	18 5	11 125	,,
,, 29	* ,, ,,	,,	19 35	12 0	,,
Oct. 3	* ,, ,,	,,	25 5	13 25	,,
,, 4	* ,, ,,	,,	33 17	20 75	,,
,, 6	* ,, ,,	,,	36 13	24 20	,,
1906.					
Aug. 22	Santos-Dumont	Bagatelle	...	Few yards	,,
Sept. 14	,, ,,	,,	8 0	,, ,,	,,
Oct. 8	Vuia	Issy	...	0 5½	Monoplane
,, 24	Santos-Dumont	Bagatelle	...	0 54	Biplane
Nov. 12	,, ,,	,,	...	0 65	,,
,, ,,	,, ,,	,,	...	0 89	,,
,, ,,	,, ,,	,,	0 21⅕	0 238	,,
1907.					
Mar. ...	Vuia	,,	...	0 5½	Monoplane
,, 16	Delagrange	,,	...	0 11	Biplane
,, 30	,,	,,	...	0 216½	,,
April 5	Blériot	,,	6 0	...	Monoplane
July 11	,,	,,	...	0 32½	,,
,, 17	Vuia	,,	...	0 65	,,
,, 25	Blériot	Issy	...	0 162½	,,
Aug. 6	,,	,,	...	0 155	,,
Sept. 17	,,	,,	...	0 201½	,,
Oct. 8	*Wels	Trautenau	...	0 250	,,
,, 15	Farman	Issy	...	0 309	Biplane
,, 19	Esnault-Pelterie	Buc	...	Few yards	Monoplane
,, 22	,,	,,	...	0 32½	,,
,, 26	Farman	Issy	...	0 835	Biplane
,, 27	Esnault-Pelterie	Buc	...	0 162½	Monoplane
Nov. 17	Santos-Dumont	Issy	...	0 216½	Biplane
,, 18	De La Vaulx	St. Cyr	...	0 65	Monoplane
,, 21	Santos-Dumont	Bagatelle	...	0 157	,,
Dec. 4	Blériot	Issy	...	0 216½	,,
,, 6	,,	,,	...	0 650	,,
,, 17	De Pischoff	,,	...	0 542	Biplane

* While not carried out under official observation, there is no reason to doubt the authenticity of these flights.

CHAPTER XXI

YEARS OF FULFILMENT—1908–1909

SANTOS-DUMONT made a memorable flight on November 12, 1906. It was a flight of 238 yards, achieved in public. It created a profound impression among a few scientific men who, unlike the majority, had not already closed their eyes against entertaining any idea of the possibility of dynamic flight. In England, as we know, the feat passed almost unnoticed. Men overlooked it, or, if they gave it passing attention, regarded it as a fluke and soon forgot it in the consideration of weightier matters. There were, of course, enthusiasts in England. A prize of £10,000 had been offered by the *Daily Mail* for a flight from London to Manchester. The Aero Club was occupied at this period solely with ballooning. The Aeronautical Society of Great Britain—the oldest in the world—was not altogether idle. Papers on various aspects of mechanical flight as well as on ballooning occupied its attention; but it can safely be said that the average Englishman was, even in 1908, ignorant of the existence of the Aeronautical Society. Ballooning was popular as an adventurous hobby among a few of the wealthy. In France, however, matters had for some time been more advanced. There, credence was given to the reports of flights by the Brothers Wright in America. In England a mere handful of people believed in them.

But if England as a whole was at this time barren soil for the seed of this branch of knowledge, not all Englishmen were alike. The most striking exception was Henry Farman, and it is worthy of note that he, by long residence in France, almost

when Farman began experimenting with his first motor-driven aeroplane, Blériot, Delagrange, and Ferber, to mention three of the principal pioneers, were also hard at work.

One of the great difficulties to these early workers was that of finding a ground suitable for experiments. At first Delagrange used to cart his machine in parts to Vincennes or the Bois de Boulogne during the night, and then, after putting it together, make his experiments. Almost invariably the result was a breakage, the repairs delaying further work for some weeks. Farman obtained permission to experiment with his machine on the military parade-ground at Issy, near Paris. Writing about this period in his career, he remarks (*The Aviator's Companion*, by Dick and Henry Farman):—

"It must be remembered that months of study and experiments are required to discover a law, a principle, or even a small detail; though after such long and patient labour the little details can be taught and revealed to others in a few minutes. . . . It took Langley two years to find out that the centre of pressure on an aeroplane in motion in no way coincides with the geometrical centre. Well, this truth was explained to me in a minute by Captain Ferber, and proved practically in five minutes by using a small piece of paper doubled up and moved through the air."

It was a common difficulty for the early experimenters in flight to find that, having obtained an aeroplane and put into it a motor and propeller, and started the motor, the machine would not rise from the ground. It would run along the ground with great energy, but no manipulation of the planes would induce it to leave Mother Earth. Every success in those days was won only after prolonged efforts and devotion. It was often only a little thing that was wrong, but it was impossible to say where lay the fault. Sometimes it was in the motor, which was not giving out its normal power; at others it was some slight error in the arrangement of the sustaining

surfaces. Farman says of his first success: "Finally I got the machine to leave the ground. This took place one day when, almost in despair, I jumped from my seat on the aeroplane seeking to give it an impetus while it was running on the ground. Though undeniably it was a coincidence, the machine did make a leap of some 50 yards. At the time several articles were published in the Paris press saying that I had made my aeroplane fly by jumping from my seat while piloting it. The assertion was not more sensible than it would be to affirm that a boat could be stopped by pulling at a rope attached to the bow."

In these days the aviator learns the art of flying under the tutelage of one who is already a master. He is not alone, or, what is far worse, the object of ridicule, and regarded as a hare-brained enthusiast. We have had occasion to read of the sensations felt on first leaving the ground by early experimenters; how, for instance, Ader was so overcome by novelty and emotion that he lost control of his machine. But many of the experimenters, and Henry Farman among them, had begun by gliding flight, a method which is well worth cultivating at the present day, since, without danger, it accustoms the novice to the control of an aeroplane, to the aspect of the ground, and to alighting.

It might be thought that Farman and Delagrange and Blériot were only imitating in Europe what the Brothers Wright had done in America already. But in important respects the work of these three aviators was on novel lines. Their machines, for instance, were of different type from the Wright. They were machines with tails, as was Santos-Dumont's first aeroplane, and there were many points of difference in which they were finding things out for themselves.

On January 13, 1908, Farman won the Deutsch-Archdeacon prize of £2000. This was for the first flight in which the aviator started from a given point, circled a flagstaff 500 metres away, and returned to the starting-point without touching the ground. To achieve a turn in the air was almost as great a step

adays, but the early flyers each had to go very carefully to work when deviating from the straight line. They soon found that it was by no means easy, and that the operation was dangerous. Henry Farman writes: "If, while turning, the aeroplane touches the earth with one of its wings a serious accident naturally occurred. That is why I was so long before trying to veer round. It must be remembered that the fact of turning diminishes the speed of the aeroplane, thus causing it to descend towards the ground." The reader will understand that it is the inclined position of the aeroplane in turning that makes the manœuvre dangerous, as one of the wings is high up in the air while the other is close to the earth unless the machine is soaring at a considerable altitude. "To ascertain the direction and speed of the wind at different altitudes," continues Farman, "I sent up numerous gas balloons more or less heavily laden; and I can guarantee the wind is much more unequal, and consequently much more dangerous, close to the ground than it is between 20 and 100 yards from the surface." After winning the Deutsch-Archdeacon prize, Farman made many experiments. On one occasion, trying to turn in a stiff breeze, the aeroplane capsized and was completely wrecked. Fortunately, the aviator was not much hurt. He then gave flying exhibitions in Belgium and America, in this way earning money for further experimental work. On his return to France he went to Chalons, and made various changes in his machine. The duration of his flights was meanwhile increasing. At Rome he remained for over fifteen minutes in the air. At Issy he flew 13 miles in 20 minutes 20 seconds on July 6, 1908, winning a prize of £400. But one of the most remarkable things he did in that year was to take up a passenger, Ernest Archdeacon, May 30th, at Ghent, winning for himself and his compani wager of £500 they had made with Charron that before t of the year a flight of one kilometre would be accompl an aeroplane carrying two men. Their flight was 1½

long. In the autumn of 1908 Farman was making flights of nearly an hour's duration. At the end of September he made a record for speed with a forty-minutes' flight at the rate of 40 miles an hour. But in the following month he made the first cross-country flight on record, and thus in a measure he is to be counted as the first aerial voyager using a heavier-than-air machine. He flew on that occasion from Bouy to Rheims, a distance of 18 miles, in 21 minutes, at an altitude which was often over 300 feet.

In a sense every one of his flights was an experiment. He was constantly making changes in the curvature of the planes and in their area. He also transformed his biplane into a triplane, but soon changed it back again. None of these points could be settled by means of mathematical theory, on paper, or even with scale models. They had to be tried in a full-sized machine with a human being at the driving-wheel. "All these experiments," writes Farman, "entailed a certain amount of danger, but, happily for me, I had not the slightest accident."

In the autumn of the same year the Wright Brothers made their first flights in Europe.

We must now turn to the first experimental work of Louis Blériot, who, chronologically considered, should come before Farman. As long ago as the year 1900 Blériot first turned his attention to flying. He built a model of a flapping-wing machine in that year, but it was unsuccessful. Its author diligently read all that was published on the subject of flight, and very soon there were the gliding experiments of Chanute and the Wrights to inspire him. The result of this was that he built an aeroplane, the Blériot II., which was mounted on floats and towed on the Seine by a motor-boat. The glider was mounted by Gabriel Voisin. Two other machines followed, and on the very day that Santos-Dumont made his famous flight at Bagatelle on November 12, 1906, Blériot was experimenting with his No. IV., a cellular biplane, and wrecked it by running into a ditch. In March, 1907, he made trials of his

was on this machine that he made his first flig
But a few days afterwards the machine was
again escaping unhurt. This machine had a
of 150 square feet, and was driven by an Ant
24 horse-power. Then came No. VI., called th
This monoplane was of the Langley type, hav
of wings at the rear of the front pair. It l
194 square feet, and its wings were covered w
ment. It flew fairly well, but was completely
tember 17th, Blériot again having a narrow es
month the No. VII. was ready for trial, this i
never being discouraged by his misfortunes.
was a reversion to the former type, but it was v
its single pair of wings having an area of 270 s
this machine Blériot had many accidents, but o
he accomplished a fine flight and made a turn
few days later, in attempting to turn too near
inner wing grazed the earth and the machine tu
over. Its pilot escaped with a few scratches a
at once set to work to design No. VIII. Th
of his really successful aeroplanes. On July 6th
a flight of 8½ minutes. Towards the end of t
replaced it with No. IX., which he showed at th
Salon in Paris, together with No. X., which was
October 31st, Blériot on the monoplane flew
Artenay and back, a distance of 17½ miles. Th
after Farman made the first cross-country flight
repeat his exploit on November 4th, during a f
into a tree and again destroyed his machine. It
he began to build the No. XI., the machine on
his historic flight across the Channel.

How many accidents Blériot had has never b
some say as many as fifty, and yet when he had
lished his type of monoplane, had crossed the

would give up competitions and exhibition-flying and devote himself to the manufacture and evolution of the perfect flying machine, there were people who criticised. Not only had he risked his person, but he had also sacrificed many thousands of pounds, the profits on his motor-car lamp and other inventions.

In the year that he flew across the Channel, Blériot made a cross-country flight of 25 miles, winning a prize of £560 offered by the Aero Club of France, and in the same year he and Gabriel Voisin were awarded the Osiris prize of £2000 for aviation research.

The name of quite another type of man now occurs in the annals of aeronautical progress. This is Léon Delagrange, a sculptor, who began to take an interest in aviation in 1905. Delagrange was born at Orleans in 1873. His father was the owner of wool and cotton mills. Young Delagrange was one of the first boys in France to possess a bicycle, and one of the first motor tricycles ever made was purchased by him. He tried to improve upon everything he had. Art appealed to him strongly, and he studied, curiously enough, at the Beaux Arts with Henry Farman and Gabriel Voisin. Little did any one of the trio imagine at that time that his name would become famous in aerial navigation. For fourteen years Delagrange exhibited as a sculptor and was awarded several medals. A work called "Love and Youth" by him was purchased for the Museum at Copenhagen. There is no doubt that he went in for flying for the love of it. Certainly he spent much money, while his rewards in the way of prizes were trivial. He was associated with the Voisin Brothers until the summer of 1909, when he became connected with Louis Blériot.

At the great aviation meeting at Rheims in 1909, Delagrange entered a Voisin biplane as well as a Blériot monoplane, but he had at that time determined to give up the biplane. It was the success of that, the first aviation meeting ever held, that did so

ticable. The spectacle of four or five machines in the air together, photographed and published in the illustrated journals throughout the world, made a profound impression, and at that meeting, too, there were seven flights of over one hour's duration. It was the beginning of a long period of aviation meetings, Delagrange flying in Belgium and Denmark and also in England, at the first aviation meeting held in this country, in October 1909, where he met Cody, who had, despite his little knowledge of mechanical science, produced a biplane with which in the same year he made a cross-country flight of 40 miles. On the very first day of the Doncaster meeting the public, very few of whom had ever seen a flying machine before, had a striking lesson in its possibilities. At the far end of the aerodrome Cody's machine was seen to descend, run along the ground and suddenly turn up on its nose, the tail sticking up in the air. It looked like a very serious accident, and there seemed every likelihood that the aviator might be killed. Delagrange, whose machine happened to be ready for flight, jumped into it without a moment's hesitation and flew to the scene of the accident. He was almost the first on the spot. Cody fortunately escaped with a few cuts.

At the time the Doncaster meeting was being held, there was an aviation meeting also at Blackpool, which suffered severely through bad weather. The Blackpool meeting gives us occasion to remember a remarkable feat by Latham, of whom we shall presently read in connection with cross-Channel flying. Up to this time aviators were regarded as fine-weather birds, or butterflies. None had ever attempted to fly in a wind of more than about 15 miles per hour. It is probable that at Blackpool the aviators were exasperated by the inaction enforced by the wind and rain. It appears that on the evening of the 21st of October Latham promised a friend that he would, at all costs, fly on the following day. He must have regarded this promise as sacred, for after some hours of waiting during a stormy morning, while all the other aviators kept their machines in their sheds and the wind

was blowing in strong gusts across the aerodrome, Latham took out his machine, an Antoinette monoplane, to the starting-point. The wind was increasing in strength. Friends went up to the aviator and tried to dissuade him from his purpose. He was immovable. He remained inflexible. The motor was started, he got into his seat, and, after one or two attempts, the wind making the run along the ground hazardous, the aviator ascended. It is an axiom of aerial navigation that to the aviator wind does not exist, that once in the air he can move freely in any direction although all the while he may be carried along with the current at hurricane speed. "To the aviator wind does not exist: it is the earth that moves." But in a high wind it is in getting off the ground and in landing that danger occurs. Again, no wind flows evenly. All winds are made up of alternating gusts and lulls, and, generally speaking, in the stronger winds the difference between the velocity of the gusts and the lull is greater than in the lighter winds. There are, of course, comparatively calm conditions of the atmosphere at times which are perilous to the aviator on account of sudden puffs of wind which seem to come from nowhere. Now an aerial vessel does not immediately take on an increased or decreased velocity of the current: there is a moment during which its inertia resists, and it is at this moment that the driver has to exercise his skill in preserving equilibrium. One other effect is that with a strong following wind the aeroplane has a tendency to come down and with a strong head wind it tends to rise. When Latham went up on this historic occasion the spectators saw a man fighting with the elements. The aeroplane tossed and swayed in the most alarming way. Its speed down the wind was computed to be over 90 miles per hour. Beating up against the wind, however, it appeared at times almost to be motionless. The onlookers were fascinated, and every moment expected disaster. Those who understood most, realised the danger most. They called to him to descend, in the vain hope that their voices could be heard. He remained flying for over ten minutes, and succeeded in landing safely. At once the aviator was surrounded

Frenchmen in tears.

Latham at this time was the hero of the flying world. He flew again in a gale at Mourmelon in the same year. He was constantly proving himself of a superior grade to his contemporaries; yet never did he win any great prize. He was, indeed, bound up with the Antoinette Motor Company, whose engine was at this period a constant disappointment. No one but a Latham could have gone on without losing heart in the fact of this tremendous obstacle. At that time he was about twenty-six years of age. He was a Parisian, although his father came from Lancashire, and he had spent fifteen months at Balliol. So like an Englishman was he in many ways that the English newspapers claimed him as one and called him "Mr." He went in for all kinds of sport, ballooning among others, and for four years he hunted elephants in the Soudan, and travelled extensively in Africa and in India. For his services to aviation he was awarded the Cross of the Legion of Honour.

The Antoinette aeroplane was undeniably a far better flying machine at that time than the Blériot, and it was only prevented from taking first rank through its unreliable motor. The aeroplane itself was far more stable in flight on account of the dihedral setting of its wings, and also because of the greater length of the fuselage and superior efficiency of the tail as a stabiliser. It had a greater degree of natural stability than the Blériot, and therefore required far less attention from the pilot. This fact is well illustrated by an accident which occurred later in Latham's career. On one occasion Chavez, the hero of the first trans-Alpine flight, flying at a great altitude on a biplane, saw mounting up towards him from the ground Latham on his monoplane. When Latham had attained a height of about 800 feet, Chavez observed the propeller of the Antoinette suddenly cease revolving. At the same instant he saw, to his horror, that Latham threw both hands over his head as if resigning himself to his fate. The monoplane then descended at its gliding angle towards the earth. At that time, as at

present, the sudden stoppage of a motor in the air on most machines required the instant and skilful attention of the pilot, who had to dip the head of the machine downwards in order to avoid falling backwards. The Antoinette monoplane, being in a high degree naturally stable, would in certain circumstances do this without attention.

About the time of the first aviation meeting in England the Comte de Lambert, a Russian, flew with great daring over half of Paris and round the Eiffel Tower. This was the first time that an aviator had flown over a great city, and de Lambert, who was flying a Wright biplane, was strongly criticised, Orville Wright himself being credited with remarking that it was "the action of a fool."

The impression made upon mankind by the conquest of the air is revealed in many ways; among others by the attitude of the Church. Early in 1909 the Archbishop of Paris, in the presence of a great gathering of distinguished people, made history by performing the first christening of an aeroplane at its launching. This, of course, had long been the custom in the case of marine vessels, so that it was quite natural to apply it to aerial craft. There were, as a matter of fact, two machines belonging to Delagrange blessed by the Archbishop at Juvisy.

The Archbishop delivered the following address, after which hymns were sung:—

"The Church blesses ships and railways. Why should she not bless these new ships destined to hover in aerial space? Has not God said of Himself in holy writ that He rideth upon the wings of the wind? We shall ask God to favour the progress of this art, to preserve its brave pilots from accident. We shall especially ask Him that, in presence of these aerian machines, souls rising to more elevated thoughts in the higher regions of truth, goodness, and virtue may also make their ascent towards God and towards the eternal mother country. In blessing these ships we are going to give them the names chosen for them by their amiable godmothers, 'Ile de France' and 'Alsace,' two poles towards which French hearts must be

of the country, the other that of a beloved temporarily, as he would hope, to the patrie."

But in Russia the Church apparently took for an aviator having had the temerity to fly ove a church, the priest with great solemnity pronc upon him. At the launch of the "Suchard" air bottle of champagne was broken over the bows o

On February 9, 1911, the following letter ap *Times*:—

"SIR,—Now that aviation in its balloon, airsl forms is making remarkable progress in many cc respectfully to make what I consider a solemn su

"There is a clause in the Litany used in t England which is as follows: 'That it may pl preserve all that travel by land or by water.' time arrived when one may hope that the words m or rather added to, so as to read: 'That it may p preserve all that travel by land, water, or by air'

"May one further hope that the Archbishop o the Pope, and the head of the Greek Church may s give instructions for the addition to that beau prayer? If so, they would, I venture to think, be of *entente cordiale* throughout the Church universe

"My suggestion cannot possibly be for one m upon as 'controversial,' and so could surely be adc hesitation.

"I am afraid that I must plead personal int the origin of my suggestion, which has arisen owi having taken up aviation and being now at th Balloon Factory at Farnborough.

"CHARLES DE HAVILLAND, *Rector of Crux East*

It was in 1909 that the first aeroplane schoc lished at Mourmelon; and here Farman, the Company, and the Voisin Brothers were very soon with more pupils than they could comfortably man

Dealing with this period we must return to Farman, who now discontinued his association with the Voisin Brothers and produced an improved biplane, in which he abandoned the vertical planes which divided the early Voisin machine into cells. Farman also introduced ailerons in the form of flaps hinged to the rear extremities of the main planes, and capable of being raised on either side, those on the opposite side being simultaneously lowered, for the purpose of maintaining an even keel in wheeling movements. They served, indeed, the same purpose as the flexible wing-tips of the Wright, the Blériot, and other machines. The Henry Farman machine rapidly came to the forefront. Record after record was made upon it, and in that year Henry Farman himself achieved a flight lasting for four and a half hours, during which he covered a distance of 146 miles.

It was in 1909 that the Wright Brothers claimed that, as the inventors of the flexible wing-tip principle, they had a right to the profits derived from the use of that contrivance, and they began to bring actions at law against other makers who adopted this principle. They obtained injunctions against certain French aviators who took machines to the United States, and a long series of litigation was commenced. It may be mentioned that Montgomery, another American, had many years before established a somewhat similar principle to that of the Wright Brothers.

At the epoch-making aviation meeting at Rheims in 1909, the all-conquering French aviators were startled at the success of Glenn Curtiss, an American, who won the Gordon-Bennett trophy for speed, although he used a biplane, which is a noticeably slower machine than the monoplane. Curtiss came naturally to aviation through his connection with the motor. He was a remarkable youth. Born in poverty at Hammondsport on May 21, 1878, at a very early age he showed quite extraordinary faculty for mechanics; but he was compelled by the necessity of earning his living to turn his hand to anything. Very soon he became a bicycle repairer and racer, and won prizes. Early

in the century he began to develop motor bicy
content himself with the most primitive appl
sheer intelligence and energy he forged ahead
record-making motor bicycles, and won many i
and created world's records. He is said at on
travelled a mile in 26½ seconds, or at the rate of
hour. Having developed a motor to such a re
of efficiency, it is no wonder that aeronautical
began to turn their attention to him. The fir
Baldwin, who was building a dirigible balloon, a
tion with Baldwin bent Curtiss's desires to the a

Dr. Alexander Graham Bell, who, under the
Langley's work, had now begun to study the f
purchased a Curtiss motor for use in propelle
Bell had made a large flying machine of an uniqu
the tetrahedral cells already described. With h
ciated Lieutenant Selfridge, J. A. D. McCurd
Baldwin (not the Captain Baldwin before ment
formed the Aerial Experimental Association, the
was to solve the problem of flight. Mrs. Bell
money, and Curtiss became director of experime
result was a biplane glider, which was complete
1908. On it Curtiss made many glides. After
driven biplane was made, and called the "Red
was succeeded by the "White Wing." There w
accidents, but most of the experiments were made
possibly afforded a safe landing for the aviato
slide along without suffering hurt. On July 1, 1
machine, called the "June Bug," was ready, and
the prize offered to the first machine in America
metre. The Wright Brothers had not entered
petition. Graham Bell of course was a Briton
McCurdy. The Association, indeed, was a joint U
Canadian affair. Many of the experiments w
Baddeck, Nova Scotia; on the fourth machine
Dart," McCurdy flew altogether some 3000 mil

CHAPTER XXII

THE STRENUOUS YEARS—1909-1910

DURING the season of Christmas, 1908, an Aeronautical Salon held at the Grand Palais, Paris, attracted engineers from all over the world. It was an occasion for reckoning up the progress that had been made. Here was a Wright biplane, upon which Wilbur Wright had been making those wonderful flights at Le Mans. Here were Delagrange, and Blériot, Esnault-Pelterie, the Voisins, Farman, Ferber, and Santos-Dumont, and, in the place of honour, Ader's "Avion," for France now hastened to claim the credit for every aerial pioneer she has produced. Towering above the aeroplanes was the great non-rigid dirigible balloon, the "Ville de Bordeaux," carrying, for picturesque effect, two guns. There was nothing British at this exhibition, for Great Britain is ever slow to move with new ideas. At this time only one Englishman, excepting Farman, had undertaken to learn to fly; that was Moore-Brabazon. But the Wright Brothers in America, and in Europe, Farman, Blériot, and Delagrange, to mention the chiefs, had been setting the world ringing with their deeds. The last day of the year was to witness the accomplishment of a great record. On December 31, 1908, Wilbur Wright made his famous flight of 2 hours 20 minutes at Le Mans.

In the autumn of 1909 the second great Aeronautical Exhibition was held in Paris. Since the first Exhibition a far greater advance had been made than any one could have anticipated. Flights of one hour and two hours had become commonplace. Farman had achieved a flight of 4 hours 17 minutes. The machine had developed, and the motor had developed. The

first of the great meetings at Rheims had been held, and it electrified the world. The average man had supposed that flying was a mere fluke, consisting of occasional lucky hops which were generally followed by a bad smash. But at that Rheims meeting there were over a hundred flights, eighty-seven of which exceeded five kilometres. There were seven flights, exceeding one hour; three of these exceeded two hours, and one exceeded three hours. Besides the leading aviators, a large number of new men were becoming famous. There were Paulhan, Sommer, Engelhardt, Le Blon, Rougier, Tissandier, Lefebvre, and scores of pupils. There had been an aeronautical exhibition in London, but the British still lagged far behind, and none of the British machines shown there were proved flyers. Before the end of 1909 there had been sixty-four flights of over an hour's duration. Much of the advance in the practice of flying was due to the increasing reliability of the petrol motor, and the period about which we are speaking is memorable for the introduction of a new type of motor, having cylinders rotating round a fixed shaft instead of the fixed cylinder and turning shaft that were at that time orthodox. It became evident that while aviation owed much to the petrol motor and to the motor car, there was every prospect that it would pay back the debt by providing an added inducement to engineers to improve the design of engines. There was a steady advance in the design of motors of orthodox type. Engineers were experimenting with entirely new methods of producing power. So great was the change wrought by the introduction of the rotary motor that it is worth while recalling the circumstances and describing this type of machine. The Brothers Laurent and Louis Seguin were the designers, and they were subsequently awarded the Legion of Honour. The title "Gnome," by the way, had been given to all their productions, including motors of the stationary type, many years before. But in order to understand the principle of the rotary motor we must know the difference between the ordinary petrol motor and the steam-engine.

The internal combustion motor differs from the steam engine fundamentally in that the expansive substance which is to drive the piston up and down in the cylinder is admitted into a combustion chamber and there exploded by an electric spark. This expansive substance is usually petrol vapour mixed with a due proportion of air.

Petrol is distilled from crude petroleum. It is a volatile liquid, and is rendered available for use in an internal combustion engine by means of a spray by which a given portion of it is readily converted into a gaseous or vaporous form, in which condition it is admitted into the cylinder with air in the proportions which render the mixture highly explosive. The valve by which this mixture is admitted automatically closes, an electric spark is produced in the cylinder either by a magneto or by a coil and accumulator, and the mixture explodes. Its expansion drives the piston along the cylinder. The piston returns and drives out the spent or exhaust gases, and is then ready for another explosion.

The petrol vapour and air are mixed in a chamber outside the combustion chamber of the cylinder, in what is known as the carburetter. Thence they are drawn into the cylinder by the outward movement of the piston. The complete cycle is as follows, and it is known as the Otto cycle from Dr. Otto, who first contrived it for a practical gas-engine. First, the outstroke of the piston, sucking explosive mixture from the carburetter into the combustion chamber. Second, an instroke of the piston, which compresses this mixture in order to make the explosion of greater power. Third, the firing of the mixture, which forces the piston back, doing work through the piston rod and crank, as in a steam-engine. Fourth, the instroke of the piston driving out the exhaust product of the explosion. The arrangements of the valves cause the inlet valve to close immediately the mixture is drawn into the combustion chamber, so that the mixture is not forced out again when the piston returns and compresses it. When the piston

has travelled as far as it can und
sion the valve reopens.

The "stroke" of the piston
the cylinder. It is usually longer
of the cylinder. As there is a
a piston can travel, it is usual t
revolutions with a short stroke
and a long stroke. A motor gi
more, revolutions to the minute.

As in the steam-engine, it is
to carry the motion of the crank
so produce continuity in the runni

The ordinary motor of 2, 4, 6, a
various elaborations, due to desigr
but the needs of mechanical flight
of new types in which automatici
since it is impossible to give the p
on an aeroplane that it is in a m
desire to save weight also has in
sorts of modifications and chang
the usual vertical or horizontal e
which the cylinders are set on the
others in which they revolve round
instead of the crank-shaft revolvin
force themselves to revolve round
work by their own revolution, their
sity for a fly-wheel, since the motio
the "dead centre." The first suc
type was the Gnome, and, since it
great advances made in aviation in
we will take it as a type and descr
works.

The working of a rotary motor
stationary cylinders that, even at
some portion of what has already b

this engine the main shaft, which in other machines revolves, is stationary. It is hollow, and through it the petrol from the tank above pours into the central part of the motor called the crank-case. Here, by means of a spray nozzle, it is converted into vapour the quantity of which increases automatically with any increase in the speed of the engine. In this crank-case the shaft carries the crank (see Fig. 20). The arms which project from the crank-shaft are called cranks. The member which joins these two projections from the shaft is called the crank-pin. Now the important business of the shaft lies at the crank, the length of which is an important factor in this, as in other engines, since it is a form of lever. On the crank-pin is mounted a disc, from the side of which projects one of the seven piston "connecting-rods." This connecting-rod is fixed, and is called the main connecting rod. While the main shaft, crank, and crank-pin remain stationary, the disc revolves round the crank-pin. As it revolves, the rod with the piston at its other end moves in and out of one of the cylinders, of which there are seven radiating from the crank-case. When the piston is pulled down the cylinder some of the explosive mixture in the crank-case is drawn into the combustion chamber, which is on the other side of the piston at the extremity of the cylinder, and as the valve is closed to its escape the mixture is

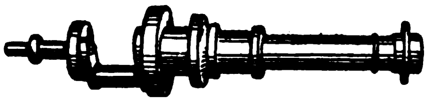


FIG. 20.—THE MAIN SHAFT AND CRANKS OF THE GNOME MOTOR.

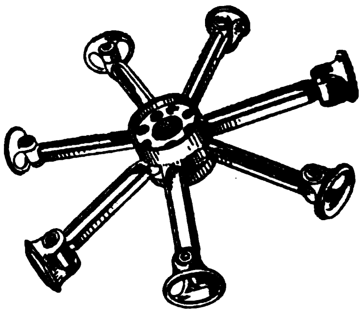


FIG. 21.—THE SEVEN PISTONS OF THE GNOME MOTOR.

of compression an electric spark ignites it, with the result that the piston is forced down again towards the crank-case. But that is only one of the seven pistons and one of the seven connecting-rods. To the disc to which the main connecting-rod is fixed are attached the ends of the six secondary connecting-rods, each of which has its own piston working in its own cylinder. The forcing up and down of one of the rods moves the crank round part of the circle, and while the crank is turning continually with the disc each of these connecting-rods with its piston is pulled up and down its cylinder, performing the same operation. Thus, each of the seven cylinders provides an explosion which assists in turning the crank and itself round the fixed crank-shaft. The seven cylinders revolve carrying with them the screw propeller, which is fixed outside.

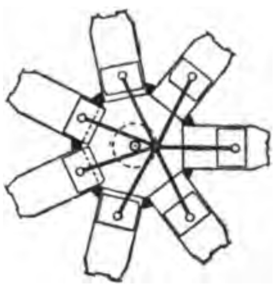


Fig. 22.—Section of Gnome Motor.

In this motor there is one complete revolution to every seven explosions—that is, 4200 explosions to the minute. The explosions do not take place in consecutive order, but as follows: 1, 3, 5, 7, 2, 4, 6. This is in order to get exactly equal intervals between the explosions. If they were taken in rotation the intervals would be irregular. The 50 h.p. Gnome motor revolves at about 1200 to the minute, and the problem of keeping the bearings oiled so that they run without friction is, as it is in all high-speed motors, serious. Pure castor-oil is used, and this is supplied through a copper pipe carried within the hollow crank-shaft. The shaft is pierced with fine holes to allow the oil to pass through to the pistons and bearings.

It is impossible to describe the mechanism in all its details here. It need only be said that when the mechanics give a turn to the propeller and cylinder, and the pistons begin to move up

produced, and directly they begin the cylinders carry on the movement. The passage of the cylinders through the air keeps them cool, and the outsides of them are shaped so as to increase the cooling effect; thus, water-cooling by means of a radiator is not necessary. Nor is a fly-wheel required, for the momentum of the cylinders provides the necessary continuation.

The needs of the aeroplane spurred inventors to evolve an engine which, power for power, would be far lighter, and efforts were made to introduce two-cycle engines. In a two-cycle engine there is an explosion in each cylinder in every revolution, instead of in every two revolutions as in the ordinary Otto cycle. By this means there is a 100 per cent. increase of the number of working strokes and economy in the weight per horse-power.

As flying became common, it became involved with the ordinary affairs of life in ways tragic, romantic, and humorous. There was, for instance, the suicide of a young Russian actress in Paris, who it seems was driven frantic by jealousy of aviation. She had recently become betrothed to the son of a Russian financier, who, in spite of her protests, went through a course of aviation at Chalons. The new art claimed so much of his time that the young lady begged him to be reasonable. As he declined to do this, she was taken to Chalons in order that she might enjoy an occasional brief moment of his company. For his part, the swain found the presence of his sweetheart somewhat embarrassing. He was whole-hearted in his devotion to flying, and disliked any distraction while he was in his novitiate. The young lady understood his frame of mind only too well. One day, while they were in Paris together, he produced a railway ticket to St. Petersburg. Whether she assumed that this was for her return or for his did not transpire. At any rate, his preoccupation, and the sense of the danger he was incurring, destroyed her mental balance, and she shot herself.

There was variety in the accidents to aviators, and it was not long before an aerial collision occurred, fulfilling what had

that two aviators, Montigny and
opposite directions collided, but,
machines were totally wrecked, neitl
exact circumstances of the collisic
perhaps the first serious accident of
Captain Dickson and Thomas were i
1910. Dickson was flying on his
paratively low altitude. Thomas
Antoinette monoplane. The mon
mediately beneath him, and the bi
obscured by the upper plane. Th
as he got lower and lower the spect
was possible. They shouted to b
naturally their cries were not heard
Swiftly the monoplane swooped c
dropping on to its prey. Then c
realised all that the most vivid ima
up concerning aerial collisions. T
monoplane crashed through the
machine, and the two aeroplanes t
inextricable confusion. Dickson s
including a fractured pelvis, and w
Yet he was restored by the arts of
to something like his former health
unhurt. This tremendous accident
future, to designers to contrive thei
could have a clear view, and to avi
their guard against such a dreadfu
another illustration of the painful ar
made each forward step possible.

Another curious accident was that
who was caught in a sudden thunder
come to ground, his machine was set
aviator was unhurt.

was the Baroness de Laroche, who learned to fly at Bouy in the autumn of 1909 on a Voisin biplane, and who obtained her certificate in the January of the following year at Cairo, a few days before the first aviation meeting ever held in sight of the Pyramids, or indeed in Africa. Previously, ladies had been taken up as passengers, and afterwards the Baroness de Laroche had many fair imitators. At the Rheims meeting in the same year she was badly injured in an accident, her machine being caught in the down-draught created by another aeroplane flying near it. She made an excellent recovery, and the shock did not prevent her from again taking the air.

Now that the general public had become deeply interested in flying and in the numerous problems provoked by it the possibility of effective aerial navigation and of ascending from and landing upon other places than large level lawns was keenly discussed. Very rapidly machines were improved, and the dexterity of airmen increased. Landing in crowded streets will never be feasible, but it is well to place on record the fact that on the 9th of September 1910, an aviator named Parisot, flying a Henry Farman biplane and carrying a passenger, made an early morning ascent in Paris, and, for the purpose of demonstrating its possibility, landed in the Esplanades des Invalides on the open space in front of the old military hospital where the great Napoleon lies. Unfortunately, a couple of carts came on the scene just before the landing, and in avoiding them the aviators knocked down two lamp-posts. This incident made a great sensation, and the police began to threaten penalties against those who endangered the security of Parisians in this way. The intrepid Parisot, it appeared, had rendered himself liable to penalties for (1) excessive speed, (2) for not carrying an identification number on his machine, (3) for not giving audible warning of his approach, (4) for having no silencer to his engine, (5) for not carrying the grey card required of all vehicles in Paris, (6) for neglecting to have a driver's licence,

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CHAVEZ CROSSING THE ALPS

The beginning of one of the most daring flights on record.

(7) for generally disobeying traffic rules, (8) fc petrol-consuming motor without interviewing had flown from Issy), (9) for damaging a mon utility, *i.e.* the gas-lamps, (10) for causing a cro and many others. The aeroplane had no le that time. It was neither a bicycle, a motor c In this case there was no doubt that the av nically a smuggler. In the same year the] Grahame-White made a landing in front of th at Washington.

Flying attracted all sorts and conditions of notoriety hunters, sportsmen, and the type of danger for its own sake. Aviation began tc law courts, and even the insane aeronaut wa One Henri Dupre, formerly a balloonist, m able attempt to escape from an asylum in While the inmates were at prayers he got roof and connected a gas-pipe to a primitive he had secretly manufactured out of odds material. Hanging to a trapeze made of a t two ropes, he succeeded in getting away, sh to the warders and others below. Shots him, but the balloon tumbled down and th recaptured.

Chiefly they were the young who were attr no doubt to the dismay of parents and guardians. indeed, at that time would have encouraged practise the new art. One famous exception w editor of the French newspaper the *Matin*, wh son, then aged eighteen years, with a Voisin bipl for passing an examination. Young Bunau V came a very skilful aviator. Exceptions also w two or three well-known aeronautical families, being of the professional class. The Spencers, o be instanced. Incidentally may be mentioned th

[redacted]

connection of every professional balloonist with the Montgolfier Brothers. I do not, of course, mean as blood relations, but merely as connections through whom the traditions and even some secrets of balloon construction passed. One famous family of aeronauts is that of the Tissandiers, who were ballooning in Glaisher's time, and who provided one of the first pupils of the Brothers Wright.

Flying attracted the poets, for it promised a new world of sensations and aspirations for them to reveal. The first poet to ascend in an aeroplane was the Italian d'Annunzio, who at once fell under the spell of its delights. In England, Rudyard Kipling took an active interest in aviation. He sat on a committee to consider safety devices, and proposed certain protective garments for aviators.

It was not long before flying had been witnessed in every country, and even by races still barbarian. At the beginning of 1910 an aviation meeting was held at Cairo in full view of the Pyramids. Strange tales of foreign magicians riding in the air, like the Djinn and Afriti of tradition, began to be told in the Cairo bazaars. Many wonders of Western inventiveness had been brought by the English, together with their gift of tranquillity and prosperity, to provinces that had for generations been the battlefield of warring chiefs—railways, the mysterious telegraph, and great works that made the arid desert fertile; but nothing seized the glowing imagination of the Oriental mind as did flying. No wonder the road to the aerodrome was a picturesque spectacle on the day of the first flights. It was lined by squatting Arabs, Nubians in white robes, native women with clamorous silver ornaments, grave turbaned Turks, and ragged Bedouins. One can almost envy the Oriental for the quality of his surprise: to us flying is a wonderful victory of science, but it soon loses its mystery; with what fancies and many-coloured imagery was it invested to the simple Arab!

Date.	Country.	Name.	Machine.	Place.
1897.				
Oct. 17	France	Ader	" Avion "	Satory
1903.				
Dec. 19	U.S.A.	Wright	Wright	Kitty Hawk, N.C.
1906.				
Sept. 12	Denmark	Ellehammer	Ellehammer	Sindholm
1908.				
May 26	Belgium	H. Farman	Voisin	Ghent
„ 27	Italy	Delagrange	„	Rome
July 18	Holland	Lefebvre	Wright	The Hague
Oct.	Scotland	Lieut. Gibbs	Dunne	Perthshire
Nov. 24	Germany	Zipfel	Voisin	Berlin
1909.				
Jan. 2	England	Cody	Cody	Farnborough
Feb. 23	Canada	McCurdy	"Silver Dart"	Baddeck, N.S.
July 25	Russia	Van der Schrouff	Voisin	Odessa
Aug. 8	Sweden	Hansen	„	Stockholm
Oct. 17	Hungary	Blériot	Blériot	Buda-Pesth
„ 23	Austria	„	„	Vienna
„ 30	Roumania	„	„	Bucharest
Nov. 15	Algeria	Métrot	Voisin	Algiers
Dec. 2	Turkey	Baron de Caters	„	Constantinople
„ 9	Australia	Defries	Wright	Sydney, N.S.W.
„ 15	Egypt	Baron de Caters	Voisin	Abbassia
„ 28	South Africa	Kimmerling	„	East London
„ 31	Ireland	Ferguson	Ferguson	Hillsborough
1910.				
Feb. 2	S. America	Bregi	Voisin	Burzaco
„ 10	Spain	Mamet	Blériot	Barcelona
„ 25	Switzerland	Engelhardt	Wright	St. Moritz
1911.				
Feb. 21	China	Vallon	Sommer	

It had been prophesied at the end of 1909 that the l' height attainable by an aeroplane was five or six thous unless some radical improvement could be made in t' It was also demonstrated mathematically that it was for an aeroplane to remain longer in the air than si' less than a year the altitude record, which had bee' rapidly week by week, was within three hundred feet, and the duration record exceeded six hour

providing already for flights of six or eight hours' duration, and the French War Office set an official test to be held in 1911 requiring that a machine should be able to carry three persons for a distance of 186 miles with 660 lbs. of spare weight. All along, the practice of aeronautics had outstripped theory. Contrivances which could be mathematically demonstrated incapable of flight were successful. On the other hand, machines which were the product of elaborate calculation refused to lift into the air. Very rapidly, however, the science of flight was being established and mistakes of theory rectified. The error had been committed of applying old formulæ to a new set of experiences. No wonder they proved fallacious.

We now come to the most stirring aeronautical event of 1910, the accomplishment of the flight from London to Manchester. This was for a prize of £10,000 offered by the *Daily Mail*. This prize had been offered as long before as November 1906. At that time flying was almost unheard of in England, and the opinion was general that it was not likely to be won for fifty years, if ever. Early in 1910 the possibility of an early attempt was discussed, but generally ridiculed. An Englishman, however, had been flying with so much success, and had acquired so much confidence in his machine, a Farman, that he determined to make the attempt. This was Claude Grahame-White, who had learned to fly on a Blériot monoplane at Pau, obtaining the pilot's certificate from the French Aero Club, and then had transferred his affection to the Farman biplane. At this time Grahame-White was thirty years of age. He was an old Bedford School boy, who had early shown a strong inclination for mechanics and motoring, and entered the motor-car industry.

No sooner had rumour associated the name of Grahame-White with an attempt to win the £10,000 prize than a Frenchman, Louis Paulhan, also a Farman flyer, began to make preparations. The Englishman, however, was first in

countrymen, who said that he would never start, or that if he did ascend would not get far on his way, early in the morning of the 23rd of April he ascended from a field at Park Royal, near Acton. In the next ten minutes the quality of his flying was such as to convince this slow-believing country that aviation was practicable. The conditions required him to fly within the five-mile radius, and in order to do this he had to pass round a great gasometer at Willesden; thence his route took him along the main London and North-Western Railway line. Nothing like this had ever been seen in England, and it is necessary to emphasise this point in order that the reader may realise what a tremendous impression the flight made. Followed by a tremendous concourse of motor cars along the roads, the aviator flew without stopping to his first halting-place close to Rugby. Here he was ahead of all road vehicles. He made his second ascent at 8.15 A.M., intending to get to Crewe, but when in the Leek valley, near Lichfield, he met with very difficult currents of air, and was forced to descend. The conditions required that he should complete the 185 miles in twenty-four hours with not more than two stops, but bad weather came on and prevented Grahame-White from completing the journey.

For the second attempt he was to have a formidable opponent in Louis Paulhan, who had exhibited a positive genius for flying. Both machines were ready by the 28th of April—Grahame-White's at Wormwood Scrubbs, Paulhan's at Hendon. Popular excitement was at a high pitch. Immense crowds gathered at the starting-points and collected along the roads. Friendly international rivalry gave a piquancy to the situation. Henry Farman, the designer of the machine used by both aviators, himself an Englishman, yet by long residence in France almost a Frenchman, divided his time between Grahame-White and Paulhan, giving each good advice and encouragement, and examining each machine with scrupulous care.

The weather was unfavourable during the early part of the day, and Grahame-White had no doubt become weary of waiting. As the afternoon wore on he went to an hotel to sleep, reports having reached him that Paulhan was not likely to start. He appears to have been badly served by his Intelligence Department, for it is certain that he knew nothing of what was going on at Hendon. His mother and sister, curiously enough, were watching Paulhan's preparations, but it did not occur to them that their hero was ignorant of them. Unquestionably Paulhan was a more experienced flyer than Grahame-White, and there was the inducement of the enormous prize of £10,000. At any rate, notwithstanding a considerable breeze, the Frenchman started at 5.21, flew to Hampstead in order to get within the five-mile radius, and then headed for Manchester. When the news got to Wormwood Scrubbs, it was scarcely credited. Grahame-White was hastily roused, and he decided instantly to start. If the Frenchman could, so could he. Not waiting to be sufficiently clad for a long evening flight, he ascended at 6.30, fifty miles behind Paulhan. But for that unfortunate delay, it might have been a close race to the finish. As it was, the Englishman got the worst of the weather, and he was handicapped by the cold. When darkness fell that night Paulhan had reached Lichfield, a distance of 117 miles, and Grahame-White descended at Roade, only sixty miles from London. It was almost dark when the Englishman came down.

Although in the result Paulhan won the prize, it can safely be said that the most striking and daring achievement belongs to the Englishman. There was little hope for Grahame-White to win unless he could make up for lost time, and he therefore decided upon an ascent during the night. No aviator had hitherto dared a night ascent or descent. In the absence of a properly illuminated platform, obviously, either operation is extremely hazardous. Grahame-White was further handicapped by the small size of the field in which his machine lay. This

the fourth extended the railway with a bridge and telegraph lines. Lamps were placed at each end of the field to mark the limits for a safe descent in case of necessity. At brief moments the moon shone between the clouds. In spite of the hour, a large crowd had assembled. I now quote from the *Times* report:—

"Grahame-White took his seat and the engine was started. For ten or twelve seconds he waited. Then, in response to his signal, the assistants released their hold and the aeroplane leaped swiftly over the shadowed field. It was a sight which remained fixed in the memories of those who saw it. The frail machine, its diaphanous planes faintly luminous above the sable ground, speeding as it seemed to almost certain destruction; the closely grouped spectators, their cheering silenced in a common anxiety as they watched the aeroplane draw nearer and nearer the ominous belt of trees at the far end of the field, and then the sudden roar, 'He's up!' Away over the black tree-tops he rose, and making a wide sweep round over the railway line, for a brief space the machine was visible silhouetted against the dark cloud-rifts before it was swallowed up in the darkness."

Three-quarters of an hour later the aviator was seen in the moonlight sky at Rugby. He was then only thirty-five miles behind his rival; but, as the eastern sky began to lighten the wind rose, and at the same spot that had given him trouble a few days before, namely, the valley of the Leek, a locality that will be marked with a warning cross on the wind charts of the future, he was obliged to descend, the place being Polesworth.

There was no necessity for Paulhan to ascend in the dark, but he prepared to resume his journey at the first sign of light. News of Grahame-White's start had been sent along the line, and it may well have been with some anxiety—for the slightest accident or misjudgment might give the race away—that Paulhan got ready. Many of the onlookers hoped earnestly

that Grahame-White would come into view before Paulhan could get away. Cheers were given for the Frenchman and counter-cheers for the Englishman, and it is related that a young lady placed herself in front of Paulhan's aeroplane and declined to move out of the way. However, she was persuaded that this was not a fair thing to do, and at four o'clock Paulhan was graciously permitted to resume his flight.

At Didsbury, a suburb of Manchester, a field had been chosen for the finishing point, and there a large crowd of people had assembled. The morning was cold and dismal. Rumours had reached Didsbury that Grahame-White had started during the night and had overtaken Paulhan. Again, that only ten miles separated the competitors. All eyes were fixed on the southern sky, and one can imagine the emotions of the watchers when at half-past five a flying machine hove in sight over the tree-tops. Many of them had never seen an aeroplane before. None could be quite sure whether it was Paulhan or Grahame-White. But international rivalries were forgotten in the desire to show their appreciation of a magnificent feat. Paulhan had such a reception that he was amazed, and when Madame Paulhan arrived at New Burnage station a few moments later in the special train which had followed the Frenchman from London, the victorious Frenchman remarked to her, "What an ovation! How truly generous these English people are!"

It is not necessary to dwell further on this historic flight. Grahame-White tried in vain to finish the journey within the twenty-four hours, but strong wind and rain prevented him. There was a great celebration in London of the victory, and, needless to say, the English aviator came in for almost as big a share of the triumph as his rival.

Paulhan declared that the money he had won would enable him to put into practice certain ideas as to aeroplane construction, and an early result was seen six months later in the Paulhan biplane.

The next diagram shows a plan view of the Dunne machine,

sense, no tail, and no elevator. Alterations in its altitude are obtained simply by increasing or decreasing the speed of the engine. It is supposed to be automatically stable, and, indeed, Orville Wright and Griffith Brewer, officially observing one of its flights for the Aeronautical Society, reported that the pilot

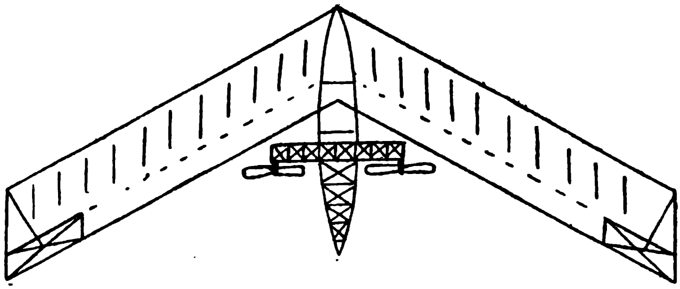


FIG. 23.—THE DUNNE MACHINE.

flew with both hands free and was able to write on a rough piece of paper certain notes, leaving the machine to take care of itself. A peculiarity of this machine is that while the planes are inclined upwards in the centre, *i.e.* near the apex of the V, they have a negative angle at the extremities. Guidance in direction is obtained by means of hinged panels at the wing tips. The stability that this form of plane possesses is no doubt due to the fact that when a side gust strikes it the tendency for the side first encountered by the wind to tilt up is almost immediately corrected by the resistance offered by the other side o the machine to the movement. Also there is no doubt that t sloped back form of the planes has the same effect as a sepa tail.

CHAPTER XXIII

SENSATIONS OF FLIGHT AND LEARNING TO FLY

IT is not easy to describe the sensation of flying. It is entirely different from that of ballooning; but perhaps before endeavouring from my own experience and that of others to give some idea of it, a few words on ballooning may prove a suitable introduction.

In a balloon the moment you leave the ground you feel absolutely motionless. It is the earth that recedes from you downward and, according to the wind, in a lateral direction. You may be travelling at sixty miles per hour, but you have no sensation of speed; there is no breath of wind in the face; the car hangs always vertically from the envelope. It is only when you touch earth again that you realise your speed, for at the moment that the car stops you feel the wind; and if it be a strong wind your repose and quietude are rudely dispelled, and your balloon, caught by the wind, heels over and drags you along the ground.

There is no sensation of height and none of giddiness. At a great height the earth has a concave appearance, but as there is no wall or line from you to the ground the ordinary sensation of looking down a cliff is quite absent. At any considerable height also you are so far away from the ground that even if you are travelling at a very great speed it is difficult to see that you are moving at all. It is the same when you are in an express train and your eyes are fixed on a distant part of the landscape; so slowly does the scene change that relatively to the swift passage of nearer objects it appears to be going in the opposite direction to them and in the same direction as the

careful observation of the end of the trail rope hanging free in the air and watch its slow passage across the map-like country thousands of feet below in order to note the speed.

The extent of the views obtainable from a balloon is only limited by the amount of haze or mist in the atmosphere. To a man standing on the seashore the horizon is 3¼ miles distant. A flag on a mast 45 feet high and 12 miles distant appears to be on the edge of the horizon. The following table shows the extent of the balloonist's vision:—

Height in Feet.	Distance of Horizon.
500	30 miles.
1000	42 „
2000	59¼ „
3000	72½ „
4000	83¾ „
5000	93½ „
1 mile	96 „

At the height of one mile, in perfectly clear weather, the balloonist can see 96 miles in any direction. Theoretically, the top of the Alps could be seen from an elevation of 10,000 feet over London. But the air is never so clear as to give such extensive vision. Balloonists over London, however, frequently see the sea.

As the balloonist reaches the higher altitudes, the sky becomes of a deeper blue, and the sun appears like a glaring bright disc on a dark background. Beautiful phenomena are seen by the balloonist. Halos round the sun and moon, rainbows, "glories," or "aureoles"—the coloured rings seen round the shadow cast by the balloon on the clouds—and splendid seas of rolling cloud above and below, reward his enterprise.

But the scenery beheld by the balloonist is an inexhaustible subject. No two voyages are like one another. Quoting from my own description in the *Daily Graphic* of a night ascent from London:—

"For some moments our eyes were riveted on the Crystal Palace, where our friends were now watching us, some of them probably feeling anxious on our behalf. Soon the lights of the Crystal Palace could not be distinguished from the myriad lights stretching away on all sides to the horizon. The lights of London's 150 square miles were displayed below us, infinite in degrees of colour, brilliance, and arrangement. Overhead the stars completed the picture. It was as if we were poised in centre of a vast illuminated globe, whose dark sides were frosted with silver and gold, the roof glittering with lights of peculiar beauty, and adorned with the crescent moon, now hanging over the south-western horizon."

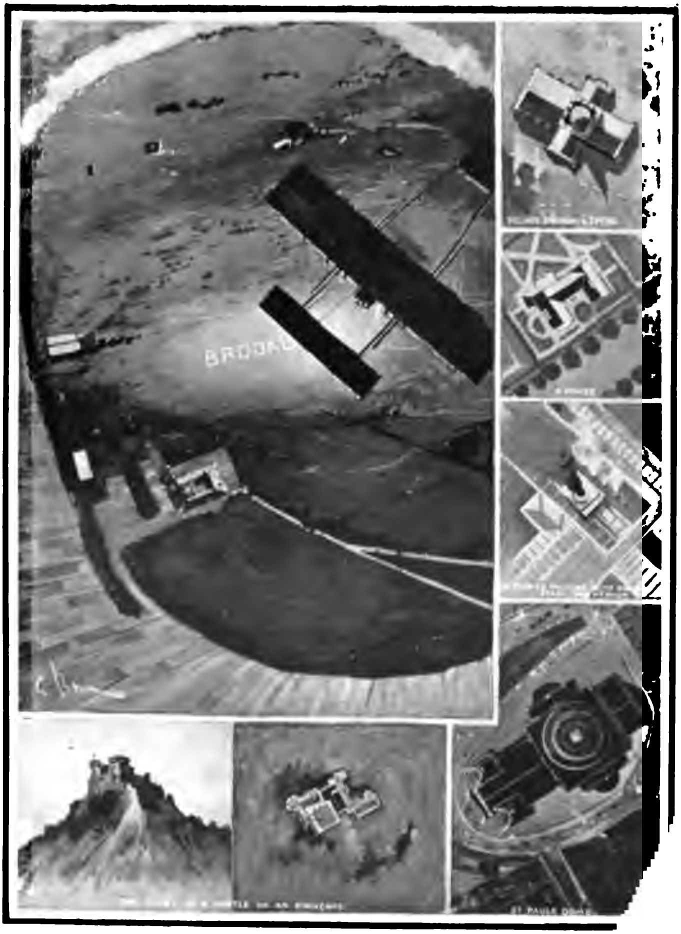
Over Essex at night the silence was broken only by the barking of dogs and the occasional whistle and rattle of a train. Suddenly a voice hailed us out of the darkness, sounding very near. We had descended near the earth without knowing it, and quickly we shouted, "Where are we?"

"Going towards Dunmow," came the instant reply.

Later on, as we were over the North Sea, crossing 360 miles of it: "At ten minutes to one we became aware of a sudden change in the conditions around us. As if by magic, summoned to appear out of the void in all directions, at a great distance from us, but about the same level, a great number of small, white, fluffy clouds appeared. The circle was complete. It seemed as if the demonstration must be intended for us. Then we became aware that similar clouds were forming another ring nearer to us. Quite motionless in relation to ourselves these weird shapes remained. They were travelling in the same wind. As for our progress, no sense of motion was perceptible. Not a tremor of the car, not a breath of wind, yet we were going at thirty-five miles an hour."

In another voyage we crossed the sea by day:—

"Sea everywhere, and no land in sight. The tens of millions of waves looked very diminutive, but crystal clear, and reflected from their facets every degree of grey and green, light and



Sphere

FLYING BY NIGHT

For the guidance of aeronauts, localities will have their names in larg on the ground, illuminated at night. The large picture shows Brookla with an aeroplane flying over it. The small pictures show how strang ance of familiar objects when seen from above.

scended nearer to it the incessant murmur of the commotion of waters reached us—a sound of unique quality and wonderful sweetness."

Dawn in cloudland is always impressive:—

"At five o'clock the light was strong enough to make a faint shadow. The balloon had fallen to 4500 feet. The cloud scenery now began to bestir itself. As if for our sole benefit, it commenced a series of wonderful groupings. Across the north-east a straight row of weird and fantastic shapes appeared, black as ink against the lightening sky. They resembled gigantic trees rearing themselves from a flat land covered with white mist. These grotesque shapes appeared to be the same clouds that half-an-hour before had passed slowly below us, then appearing indefinite and fleecy.

"The dawn grew nearer, and a red tinge appeared behind the row of cloud-trees, which became blacker and more sharply defined. A beautiful green hue appeared above the red. To the south the clouds were bluish-grey. The stars were still very brilliant.

"Almost suddenly, at about six o'clock, the row of strange trees lifted up to a higher level. The balloon's altitude remained the same. Imperceptibly the tree-clouds disappeared, and a series of mysterious and ever-changing clouds took their place. One slate-grey, ponderous-looking mass occupied a giant's share of the northern sky slightly below us, but with its topmost peaks and domes far above our level.

"It is impossible to give any idea of the immensity an variety of these changing scenes. Nothing like them could seen from the ground. In the south a limitless stretch of cl peaks look like Switzerland moulded in snow. The impr of distance conveyed by it was wonderful, and probably c extended to 150 miles or more of cloud."

Infinite is the variety of cloudland! Here is anoth

"Across the light in the east, regiments of vapoury figures slowly stalked. It was easy to imagine that these grotesque shapes were inhabited by spirits akin to their weird forms. There was strange commotion in the field of grey fog. Wisps of thin cloud would suddenly rise here and there, and as the light increased the cloud-shapes became better defined. Never at rest in the general movement eastward, varying currents of air carried some portions of the cloud area faster than others. There were other movements of irregular surface up and down. The woolly hillocks passed and repassed each other, rose and fell before each other, and, against the background of the lightening sky, they appeared like small moving pasteboard targets in a shooting-saloon, only white and soft-edged like frisking lambs."

Passing over Germany at night:—

"At a distance villages and towns were mere blotches of milky light in the darkness. As we approached one it would slowly grow, the blur resolving itself into a group of tiny points of light, becoming larger and larger, and developing in character every minute. In the case of a large town the effect was very striking. What had appeared a small blur of light would extend until it covered half the visible area below with lights of every possible shade of yellow and white and the bluish-white of electric lamps.

"Later the country seemed to be almost deserted. Only occasionally could we hear the barking of a dog or the roar of a train. When above the clouds silence seemed absolute. We appeared to be going in the same direction as the clouds below, only faster than they. It was a curious race between the balloon and the patches of vapour, and the balloon never failed to overtake and to pass any point in the diversified field of grey upon which we set our eyes. At rare intervals through an interstice in the clouds we caught a glimpse of a cottage light."

In a night voyage over England a remarkable experience befell us, the balloon sailing near the ground and disturbing a vast number of pheasants, partridges, and water-fowl, whose

amounted to a deafening volume of sound. Dogs barked, and we heard the tinkling of sheep-bells and the trampling of horses over turf. Coveys of partridges created sudden disturbances as we approached. We heard the peewits' shrill calls and the alarmed twitter of many small birds. It was interesting to observe that the perfectly silent passage across the sky of our balloon was sometimes sufficient to arouse these sleepers. We became enveloped in thick fog. We could not see any habitation, but once the sound of a man's cough reached us, and we constantly heard small birds twittering and the calls of water-fowl.

It is impossible to describe the innumerable small entertainments, and the constant anxiety of a night in the air under these circumstances. Fog is the balloonist's particular enemy, and although we were fortunately not imperilled by it, it certainly caused us much anxiety. Fog all around, above and below, and suddenly, close to one's elbow, as it seems, the bell of a church clock chimes three o'clock. There is the constant inquiry, "Is our course the same?" and the eager watching for a momentary clearing of the fog in which to take an observation.

Aerial travellers will be out in all weathers. Here is the description of our cold night over Russia:—

"We were huddled up in corners, keeping our electric lamp ready for reading the aneroid, the glass of which was coated with ice, which had frequently to be rubbed off. Our caps and coats were thick with snow, and altogether a colder and gloomier aspect of affairs could scarcely be imagined except in the Arctic Circle. Steadily we climbed to 11,000, 12,000, 13,000, 14,000 feet, each thousand taking no more than ten minutes to accomplish. As steadily the thermometer went down to 5° Fah Fifteen thousand, 16,000 feet high, and the thermometer d to zero, beyond which point it would not indicate, for so a cold had not entered into our calculations.

"Even at this height the snow was falling. Thro

feet we had forced our way upwards against it, in spite of our increasing burden. Less rapidly the aneroid indicates that we crept up to 17,000 feet, and 200 feet above that—17,200 feet—and the temperature probably at 2° Fahr. below zero.

"I think we were all worn out by the exposure and the hardships, and it is likely enough that the rarity of the air at this altitude of over three miles—higher than the highest mountain in Europe—may have distressed us a little. It was easy to imagine strange forms in the blackness, out of which streamed cold, light particles touching our faces and clinging to our clothes: there a gigantic monstrous shape floating by; below, a dimly seen palace, and a woman descending its marble steps, finding her way by the light of a lamp."

Entirely different is aeroplaning. My own first flights were as a passenger towards the end of 1910 at Brooklands, where I took my first photograph from an aeroplane, and at Hendon. My first cross-country flight was on a "Bristol" military biplane under the care of Archibald Low, who took me from Amesbury, Wiltshire, over hill and dale and woods and pastures—and Stonehenge!

The circumstances that placed one of Great Britain's first aviation centres in sight of Stonehenge, that mysterious monument of ancient times, must surely have been something more than chance. So dramatic and romantic an encounter between the ghostly past and the mightiest and most modern of scientific miracles might well have been arranged by a supreme artist weaving strange pictures in the loom of time. We sped swiftly through the air some hundreds of feet directly over Stonehenge. Behind me the roar of a mighty Gnome engine that impelled this great machine; around me the buoyant wings of the aeroplane obeying the lightest touch of the hand of the pilot in front; and, tearing past like a gale of wind, the frosty air that held us up yet seemed to strive its utmost to bar our way. Towards the end of the journey Low stopped the engine and brought the aeroplane down in a steep vol-plané to a lower

Then he started the engine again, and we resumed skimming along a few feet from the ground.

In an aeroplane there is no sense of height except that deduced from the apparent size of familiar objects. The rush of wind is ever on the face, and in cold weather it is very cold indeed. But always it is exhilarating.

It is as easy to learn to fly as to learn to ride a bicycle; but as a blunder in a flying machine is apt to result in broken wood and wire, so it is necessary in learning to fly to proceed by comparatively cautious steps. In learning to ride a bicycle the pupil is almost from the beginning entrusted with the sole command of the machine. He cannot easily damage it or seriously hurt himself. The vast majority of cyclists have become proficient riders without doing any damage; and this can now be said also of the great majority of flight pupils. Take my own case, and it is typical of that of the average pupil. I learned to fly, and in the process I did not break wood or strain a wire up to the time of obtaining my pilot's certificate—I was, by the way, the fifth Englishman to do so under the new stringent conditions imposed in 1911 by the International Aeronautical Federation, and I am No. 70 on the list of British aeroplane pilots—I never did more damage than could have been repaired for five shillings, and this was not due to a beginner's blunder, but was simply what a golfer would call the "fortune of the green": it was done in a bad landing brought about by my encountering thick fog, in which I flew perilously near to some telegraph wires and was obliged to make a quick descent. I learned to fly on a "Bristol" biplane at the school near Amesbury on Salisbury Plain.

Whether ballooning is a very valuable preparative for mechanical flight I am unable to say. It cannot be denied tha it has some value, and I found that the idea of leaving Mot Earth for an excursion into the air had, of itself, no te That many people are appalled at the prospect is und

make a balloon or an aeroplane ascent have shown themselves indifferent to far greater risks on *terra firma*.

Flying has been compared to many things; but, in truth, no comparison is good. Let me, however, correct one or two common, but false, notions concerning it. There is, as I have said, no sense of travelling at a great height: there is not the slightest danger of giddiness. To me this gave no surprise; for, as every balloonist knows, it matters not whether he look down from twenty or from two thousand feet the sensation of height is absent. To take my own case, I cannot look down a hundred-feet precipice for many seconds without being compelled to turn back from the edge, but I can look down from a balloon that is 10,000 feet above the ground for half-an-hour at a stretch without feeling a qualm. And I can guarantee the same immunity to my readers.

In an aeroplane flight, when the engine starts, the noise, vibration, and sense of speed as the machine shoots forward over the ground are certainly tremendous. Some people find them at first somewhat unnerving, but even nervous people soon get used to them. It is almost impossible to perceive the exact moment that the machine leaves the ground; only there is, with the increased speed along the ground and when flying, a rapid diminution of the noise, a swift decrease of the vibration, until the machine is simply gliding with perfect smoothness and there is nothing to inform you of the speed except the rush of wind upon the face. For as you rise from the ground it does not continue to rush beneath you, and the higher you get the slower do you appear to be moving. As to one's sensations in full flight, there is the growl of the engine, which, with use, soon becomes unnoticeable, and with this there is the steady rush of air over the planes giving forth its own peculiar music. Sometimes the machine rocks slightly laterally and in the path of flight, but the movements are as a rule very small and are corrected as

to sink slightly and suddenly in what is known as "a hole in the wind"; and at times one hears a slight thumping as with a muffled mallet on the planes, caused by the buffeting of the air.

The pupil's lessons begin with passenger flights, followed by instructional flights during which he is allowed to place a hand upon the lever in order to feel the movements and to understand better what the pilot is doing. When he has obtained experience the time approaches for him to make his first solo ascent, which, as can readily be imagined, is a great event in his life. Having made his first solo flight, no matter how short, or how confused his feelings, the battle is more than half over. His second flight is infinitely easier, and with the third and fourth he feels quite at home in the air. From that point his progress is rapid, for there is nothing in the least difficult in the control of an aeroplane except in high wind. The ground-work was laid while the instructor was deeply imbuing him with the idea of flying and compelling him to realise, so as to make a second nature or an instinct of making all his movements very gently and nicely but also as quickly as required.

After my sixth or seventh flight with the machine in my sole charge I was ready to fly for my certificate. This, perhaps, would have been "pressing the game" somewhat; and, as a matter of fact, it was not until I had made eleven solo flights, including the first two straight hops which are scarcely worthy of the name, that I was put through my tests. These tests required that the pupil shall make two separate flights, each consisting of five complete figures of eight; that in one of them he should attain an altitude of at least 50 metres (167 feet); and that from each he should land with the motor cut off and come to a halt within fifty yards of a spot previously designated. Two of us pupils were flying for our "brevets" on the first test, and as my fellow pupil had made two of his figures of eight before I was sent up, it was necessary to fly high in order not to

embarrass him. So that in my first test I flew at a height of 700 or 800 feet. The second test took place three days later, namely, on the 23rd of April 1911. It had been windy all day, but towards sunset the wind fell to about ten miles an hour, and I declared my intention to make the attempt, the official of the Royal Aero Club being present and everything ready. As it may give the reader an idea of what flying in difficult conditions is like, perhaps I may be pardoned for describing at length my final test flight.

I had no sooner left the ground than I realised that the wind was stronger than it had seemed. As a matter of fact the wind was rapidly increasing. Rising against the wind just after crossing between the two mark-flags the machine almost stopped in its career. It reared up considerably and rolled from side to side, calling for quickness and strength to keep it in even flight. I soon found that going against the wind the speed of the machine, judged from familiar landmarks below me, was not more than 6 or 10 miles per hour; the wind, therefore, was about 30 miles per hour; also it was clear that I was to have a severe tussle. But finding that I could manage to fly I kept on, taking care to go far beyond the mark-flag before attempting to turn; for immediately the machine had its side, and then its tail to the wind it would be driven along at a great pace. This, of course, proved to be the case, and it was only by care that I managed to effect the turn in time to cross between the flags again. Also, with a following wind the machine had a strong tendency to come down to the ground. This, by the way, would not be the case were wind to blow in an even current of uniform velocity; nor would a machine tend to plunge upwards when flying against the wind were this the case. But, as the reader knows, all wind is made up of alternations of small and comparatively high velocity, the variation in most cases amounting to 30 per cent. of the average velocity; and this factor, taken in conjunction with the inertia of the flying machine, accounts for the phenomena I have mentioned, as also it accounts for at least

80 per cent. of the difficulties and dangers, such as they are, of mechanical flight. But, further, I found naturally that in going with the wind the speed relatively to the earth was at least 70 miles per hour, and it required considerable strength and quickness to keep her on her course. At the same time, whether flying with this strong wind abeam, or ahead, or behind, the sensation of wind on my face was unvarying, so that if I had shut my eyes I could not have perceived whether I was flying in one direction or another relatively to the wind.

After completing one figure of eight, taking care not to bank the machine up in turning with the wind from the outside of the turn, but taking advantage of having the wind on the inside of the turn when on the opposite side of the circle to bank the machine up considerably and so to some extent prevent the side-drifting, I decided to continue; and I was the more desirous of continuing because not only is every pupil anxious to win his certificate, but I saw my instructors, Jullerot and Collyns Pizey, together with the other pupils standing between the mark-flags, clapping their hands in encouragement every time I crossed. One figure eight was like another save in detail. I endeavoured to change my course somewhat and find out if it were possible to avoid certain difficult spots, but in each case it was necessary to make a wide detour against the wind in order to gain room enough to turn, and at the end of the eight away from the wind I was each time drifted half a mile or so out of my way. In flying against the wind I increased my altitude as much as possible in order to allow for the downward course with the wind. In the fourth eight I experienced a "side-slip." In turning to the right with the wind on the outside, although careful not to bank the machine up on the left, the wind, nevertheless, caught it and threw the left wing up at such an angle that the machine began to slide downwards to the right. Good teaching came to my rescue. I turned the machine hard into the wind, *i.e.* to the left, and corrected the inclination by a very pronounced movement with the ailerons. After a moment my efforts had

the desired result: the slip was checked with still fifty feet or so to spare, and the machine righted itself.

The flight lasted 25 minutes, whereas in ordinary conditions the trial can be got into 16 minutes with a machine of the type I was using. But I had won my brevet, and had gained experience of flying in wind which would certainly prove valuable. Also, I had gained a confidence in the machine and in flying which were well worth the trouble.

Wilbur Wright described the sensation of aviation as "something more exhilarating than motoring, easier and smoother, with a movement of added dimension.

"At a height of 100 feet you feel hardly any motion at all, except for the wind which strikes your face. If you did not take the precaution to fasten your hat before starting you have probably lost it by this time. . . . You make a very short turn, yet you do not feel the sensation of being thrown from your seat, so often experienced in automobile and railway travel.

"The operator stops the motor while still in the air. . . . The motor close beside you kept up an almost deafening roar during the whole flight, yet in your excitement you did not notice it till it stopped."

Frantz Reichel, writing in the *Figaro*, recorded his impressions in the following manner:—

"I have known to-day a magnificent intoxication. I have learned how it feels to be a bird. I have flown. Yes, I have flown!

"I am still astonished at it; still deeply moved. For nearly an hour I have lived that daring dream vainly pursued through all the ages by audacious man.

"When we started there was a sudden impression of a plunge into space which gave me a *coup à l'estomac*. Then suddenly it was all very smooth, a cradling amid the thunder of the motor. I did my utmost to see well, to feel everything radiant, but not daring to move or even to stir.

"We advanced towards the horizon, the dunes, the hills, the

open; the air bathed me but did not whip me. This was the first impression a mile from the starting-place, above a magnificent carpet of heather.

"I hung out my head and looked at the crowds below. They were waving handkerchiefs. Gently, with my elbow firmly fixed to my side, I moved my arm in a mechanical manner, like a dummy. I let go of the iron bar by which I was supporting myself. It was quite safe to move, and I risked more and more.

"The sun is sinking, we are flying in the twilight. From the ground appears and descends a slight mist, which covers the big glens with a white carpet. It is the doubtful and suspicious hour of the day.

"The night has come. It is getting dark, and the moon is rising. Silence reigns over the woods and fields. I cannot believe that it is I who am flying in the night. The sensation is so magnificent that I long to pass several hours in such a manner.

"Night is now complete. Cyclists, peasants, and chauffeurs have lighted their lanterns or their torches. And this illumination pierces through the darkness. But we fly on, chasing our shadow, which the moon throws before us.

"If I had known I should have brought a pencil and a writing-block with me, and have recorded my impressions. One is able to write much more comfortably in an aeroplane than in a train or motor-car."

Finally, Frank Hedges Butler, the founder of the Roy Aero Club, very happily describes the sensation as that skating on very clear ice and seeing with perfect clea the bottom of the lake.

CHAPTER XXIV

CROSSING THE SEA

THE first flight across the English Channel by Blériot in July, 1909, was a tremendous achievement, and, unlike some other great deeds aeronautical, it was immediately appreciated by the whole of Europe for its true significance. Before telling the story of that wonderful flight, which was not only a mechanical achievement, but an act of courage, born of confidence and "faith in his star" by a hero, it is worth mentioning that over a hundred years before a claim was quaintly made by an Italian of a flight across the Channel. In the municipal library at Bergamo there is a curious manuscript describing an alleged flight across the Channel by an Italian monk in 1751. The subject of the manuscript is also to be found in an old book, *The History of the Year 1751*, printed at Amsterdam at the cost of F. Pitteri, publisher, of Venice. In other literature of the time other references are found to the same alleged flight, which was, according to one author, performed by Father Andrea Grimaldi, of Civita Vecchia, who came from the East Indies "with a marvellous machine of his invention, fashioned like an eagle riding, on which he flew from Calais to London in 1571, at the rate of six leagues an hour." The manuscript is a letter, of which the following is a translation:—

"LONDON, *October* 18, 1751.

"MY DEAR FRIEND,—A few days ago a man of the most remarkable character arrived here from the East Indies by way of Lisbon. They say he is an Italian monk, a native of Civita Vecchia, Andrea Grimaldi by name, about fifty years of age and of medium height. Under the orders of the Pro-

vincial Fathers and of the Propaganda he spent about twenty years in travelling in the Furthest East, where, in the intervals of his religious duties, he devoted himself for fourteen years with much labour and expense to perfecting the construction of the most marvellous and wonderful machine which mechanical and mathematical art could produce. The machine is a box of the most curious workmanship and texture, which, by means of clockwork, rises into the air and flies with such lightness and speed that it can travel at the rate of seven leagues an hour. It is made in the shape of a bird. The wings measure 22 feet from tip to tip; the body is composed of pieces of cork skilfully put together, firmly joined by wires and covered with vellum and feathers. The wings are made of catgut and whalebone, and are also covered in vellum and feathers, and each wing folds in three joints. In the body of the machine there are contained thirty wheels of singular workmanship, two brass globes, and some small chains which alternately expand and contract; and by the aid of six vessels of brass containing quicksilver, which runs into various channels with internal divisions, the artist is able to keep the machine in equilibrium and properly balanced. Then by means of friction between a properly tempered steel wheel and a large and powerful magnet the whole machine moves forward with a regular motion, for it can either fly in a gale or in a dead calm.

"This machine is directed and guided by a tail seven spans long, which is attached to the knees and ankle of the driver by narrow leather straps, and so by stretching his legs to the right or left he can move the machine to whichever side he likes. The head is of the most beautiful shape, and represents that of an eagle. The beak is made of horn of a peculiarly transparent kind. The eyes are of glass, and so natural that they appear to be alive as they move on their axis by means of two wires inside the beak. Eyes and beak are in continuous motion during flight. This lasts only three hours, and then the wings gradually close. When the driver perceives this

he lets himself fall gently to earth upon his own feet in order to rewind the machine.

"He says that if by some ill-luck one of the wheels jammed, or the framework were to break, he would fall headlong to the ground. For this reason he does not rise much beyond the height of the trees, and he has not run the risk more than once of passing over the sea, which he did from Calais to Dover, arriving the same morning in London, whither he said he was drawn, partly by curiosity, partly by the fame of our learned men and professors of mechanical science.

"He has already had an interview with two of the leading men in that branch of science who have seen his machine at work, and he has promised to send them by next Christmas an entire and complete set of wheels more accurately finished and not so liable to accidents, which will only occupy half the space of the old ones, with this difference into the bargain that they will work more quietly and will continue revolving on the average of six hours, so that the machine will fly at the rate of thirty miles an hour without rewinding.

"The exquisite choice of the feathers which adorned this bird surpasses the imagination and skill of the ablest painters. The most beautiful variety of colour and shade is there represented—brilliant sky-blue, gold, ruby, green, brown, and white, and these colours all blended in such delightful fashion that the like has never been seen before. The inventor recently made a flight from the Park of London to Windsor and returned thence, the whole expedition taking less than two hours. On his Majesty's birthday he purposes to fly from the top of the Monument at the sixteenth hour, circle round the City of London, and land in the Park about the eighteenth hour. What I have told you is true, though it is not all, because time fails me. Farewell."

But to return to what we know is fact. Attracted by the prospect of winning undying fame and the prize of £1000

Sphere

GUIDING THE AVIATOR ON HIS WAY

A white arrow on the ground near the coast pointing the shortest way across the Channel, and large enough to be seen from a great height. A code of ground signs will be used to indicate landing-places, danger, weather forecast, and so on.

offered to the aviator who first flew across the Channel, Hubert Latham, a Frenchman, who had, we are rejoiced to know, an English upbringing and education, waited day after day with his Antoinette monoplane on the cliffs at Sangatte, near Calais, for calm weather suitable for the flight. His chance came at dawn on July 19, 1909. A French torpedo-destroyer steamed out into the Channel ready to give assistance if required. Latham started just before seven o'clock, having been delayed by the fog. The attempt was doomed to failure. His motor failed him when he was no more than eight miles from the French coast, and he was forced to glide down into the water, which he did, fortunately without mishap, the machine floating until the aviator was rescued.

In his own account of his failure which appeared in the *Daily Mail*, Latham describes how he was just preparing to take a photograph with a small camera with which he was provided when he heard disquieting sounds in the motor.

"Instantly I gave up any idea of photography, and did everything I could to remedy the defect. I examined all the electrical connections that were within my reach. I tried also to alter the carburation and ignition of the engine. But it was all in vain: in a few seconds my engine had stopped entirely. It was maddening, but I was helpless. Never before had the engine played me such a trick after so short a flight.

"At the moment my motive-power was taken from me I estimate that I was about 1000 feet up in the air. Thus, even though my first attempt at the Channel crossing failed, I think I can claim to have established a record for high-flying in an aeroplane. Then I glided down to the surface of the water. There was nothing else to be done. I came down, not in a series of short glides, but in one clean, straight, downward slope. It seemed quite a long time to me before I struck the water. My speed at the moment of impact was about forty-five miles an hour.

"The machine was under perfect control during the descent.

Instead of diving into the sea at an angle I skimmed down, so that I was able to make the contact with the sea with the aeroplane practically in a horizontal position. It settled on the water and floated like a cork. I swung my feet up on to a cross-bar to prevent them getting wet. Then I took out my cigarette-case, lit a cigarette, and waited for the torpedo-destroyer to come up."

Meanwhile Louis Blériot, the designer of the famous Blériot monoplane, spurred on by Latham's failure, prepared to make the attempt himself. His opportunity came on the following Sunday morning, and so little expected was it by the general public that few witnessed the start and still fewer the descent. Blériot's starting-place was Barraques, which, curiously, is reminiscent of the British occupation of Calais, and is a corruption of the English word "barrack." It is a small village two miles west of Calais and about four miles east of Sangatte, Latham's starting-place, where a tall chimney marks the commencement of the abandoned undertaking of the Channel tunnel. At four o'clock in the morning Blériot, who was suffering from lameness caused by an accident a few days before, ascended in his machine and made a trial flight of a few miles. Then he came down and waited for the sun to rise, the conditions requiring that the flight should take place between sunrise and sunset. A light breeze was blowing from the south-west when the daring Frenchman started on his flight across twenty-one miles of sea. In clear weather the coast of England is clearly discernible from the sand-dunes at Barraques, but on the morning of July 25th the weather was hazy. A French torpedo-boat, however, was in attendance, and she had already steamed out into the Channel when Blériot started. Describing his own sensations he said afterwards:—

"I had no apprehension. The moment is supreme, yet I surprise myself by feeling no exultation. Below me is the sea, the surface disturbed by the breeze, which is now freshening. The motion of the waves beneath me is not pleasant. Within

ten minutes I have passed the torpedo-boat, and I turn my head to see whether I am proceeding in the right direction; but I see nothing—neither the torpedo-boat, nor France, nor England; I am alone. For ten minutes I am lost, unguided, without compass."

It was when this episode of the voyage became known that the true nature of Blériot's feat was realised. He was, indeed, totally unprepared for such an enterprise. Having lost sight of all save sea and sky there was absolutely no means of knowing whether he was steering east, west, north, or south. Like the lost wanderer on the prairie he might have travelled constantly in a circle until weariness overcame man or machine. He says· "My hands and feet rested lightly on the levers. I let the aeroplane take its own course, and then, fifty minutes after I left France, I saw Deal, which was far to the east of the spot I intended to land upon." Near Deal Blériot saw a line of British submarines under the water accompanied by two destroyers, and he remarks, "When you are up in a balloon or aeroplane you can see very deep into the water."

Seeking Dover he flew along by the high cliffs slowly, because the wind was now almost directly opposed to him. Then, coming to a gap at St. Margaret's Bay, he found a suitable landing-place. He was seen here by only one man, a French journalist.

The crossing of the Channel has since been shown to be an easy undertaking, but we must remember the difference between the machine and the motor used by Blériot—the Bleriot XI. and the early Anzani, 25 h.p.—and those of the present day. His motor, indeed, was one of most uncertain quality. Throughout the journey he was in peril, a fact of which he was perfectly aware. It was, as I said early in the chapter, an act of heroism inspired by his enthusiasm for the conquest of the air.

A great public welcome awaited Blériot in London, and tributes to his achievement came from all parts of the world. In addition to the *Daily Mail* prize of £1000 he won the

Ruinart prize of £500. His aeroplane was exhibited in London, thousands paying for admission to see it; and on the spot where he alighted near Dover a memorial in stone, taking the form of the historic machine, was let into the turf. The machine itself eventually found a home in the Conservatoire Nationale des Arts et Metiers in Paris.

On the morning after Blériot's Channel flight, Latham tried again and failed, but brilliantly. His ascent was observed by thousands of spectators, enthusiastic in spite of the rain that was falling. They saw him start and speed away at nearly twice the velocity of the Blériot monoplane. Indeed, in twenty minutes' time from the start Latham was close to the Admiralty pier at Dover. The crowds of watchers on the English coast then saw the aeroplane suddenly turn and swoop downwards. It came forward oncemore, and then, like a wounded bird, took a series of lurches and glided into the water. There was a race to rescue the aviator, who was found standing up in his wrecked aeroplane calmly smoking a cigarette in spite of a deep cut on his face caused by the wire of his motor goggles, which were smashed in the fall. The cause of Latham's unfortunate failure was his motor. Needless to say, he received unbounded sympathy.

The next aviator to cross the Channel was Jacques de Lesseps, the youngest son of the engineer of the Suez Canal, who accomplished the feat on a Blériot monoplane on May 23, 1910. Meanwhile, the world was asking when the crossing would be effected by an Englishman. They had not long to wait. On June 2nd the Hon. C. S. Rolls, a son of Lord Llangattock, flew from Dover to the French coast, near Sangatte, and, without landing, turned his machine and flew back to England, thus handsomely beating all previous oversea flying. Rolls used a Wright biplane.

As I was personally associated with this flight and, on the French coast, arranged a suitable place beforehand for the aviator to land upon in case of need, and also arranged the

signals for which he was to make on nearing the French coast, this historical flight has made an indelible impression on my mind. I take leave to quote from my account which appeared in the *Times*. I had waited for two weeks with my signalling flags, and during that time high wind had prevented Rolls from starting. On the evening of June 2nd whilst looking through my binoculars towards Dover I was startled by shouts and exclamations raised by some workers in a distant field.

"The aeroplane was far to the west about four miles distant, conspicuous against a lovely opalescent sky. This was at 6.58. I waved a white sheet to guide the aviator, and this was apparently seen, as his course was altered towards the east. He passed the coast at 7.5, and was greeted by shouts. He went on inland for a third of a mile, and then turned north-west, apparently to fly down the Channel. He was flying at a height of about 1000 feet, the fragile object at that distance having a peculiar beauty. Some anxiety was caused by the fact that no torpedo-boat was in sight; but slowly the aeroplane shaped a better course, and I now ceased to signal. Rolls evidently intended to surpass Blériot and de Lesseps by making a double journey, and it was a proud moment for myself and for the few English people there. The French spectators were enthusiastic, for they realised that a double crossing of the Channel was a great achievement.

"With our binoculars glued to our eyes we watched the aviator's progress. It was a fascinating task. There was the great expanse of sea and sky. To the right a cluster of warships marked the scene of the sunken submarine and the operations for its salvage, a sad and gloomy reminder of the perils of the sea. A dazzling sun cut a path of burnished brass to the horizon. The heavens were alight with the tenderest hues of green, blue, orange, mauve. There was a curious rainbow effect on cirrus clouds high in the west, and right against it there was the aeroplane speeding to its goal alone in the great expanse.

Our hearts trembled at the thought of the vagaries of a motor. There was still no sign of the torpedo-boats that were to attend the flight. His course was clearly too westerly. For half-an-hour he could be seen with the naked eye, but with binoculars we clearly saw him for fifty-five minutes of his return journey. At length the aeroplane became the merest speck twenty miles away. We believed we saw him descending. Towards the end his course took him nearer the crimsoning glory of the sun, and he vanished finally under a haze to the right of Dover Castle. At that moment the twinkling lighthouses of Dover and Calais became visible in the dusk of eve.

"We turned back to Calais, and driving through Barraques were hailed with cheers. The women clapped hands and waved handkerchiefs, a generous tribute to the English, whose long-postponed demonstration of capacity for airmanship is rather a local joke."

Six weeks later poor Rolls was killed under circumstances narrated elsewhere.

Early oversea flights were Loraine's passage of the Irish Channel on September 11, 1910; Svendsen's crossing of the Sound; Outochkin's passage of the Gulf of Odessa; Curtiss's flight over Lake Erie; and Sopwith's cross-Channel flight—all in the same year.

Moissant's cross-Channel flight, which was part of his Paris-London voyage, and Grace's disastrous attempted crossing are described in other parts of the book. M'Curdy, the Canadian aviator, flew nearly all the way from Key West (Florida) to Havana on January 30, 1911. He descended on to the sea ten miles from his goal, having flown about 100 miles.

Other early oversea flights were the following: From Nice to the Isle of Gorgona, about 150 miles, on March 5, 1911, by Bague on a Blériot monoplane; and from London to Paris, crossing the Channel at Dover, on April 12, 1911, by Prier on a Blériot monoplane.

CHAPTER XXV

CROSS-COUNTRY AND OVER-MOUNTAIN FLYING

ALTHOUGH the foundations of the science of dynamic flight were being laid and scientific men were coming to agreement on many points that were formerly contentious, it was recognised by the more advanced student at this time that certain important questions remained very open. At a superficial view it appeared that the aeroplane was the final solution of the problem of flight, and that development lay in improving this type as regards general construction and the motive-power. Some leading authorities, however, kept an open mind. They pointed out that some of the best flyers among the birds evidently possess knowledge that has not been penetrated by man. They said that the flight of birds has never been understood, and that the labours of such inquirers as Pettigrew and Marey will one day be regarded as quite elementary. They said: "We do not yet understand the nature of the air, still less do we understand its behaviour as the atmosphere of the earth; we do not know precisely what are the motions of the wing of a bird in flight; we are unable to understand how it is that the gull and the albatross maintain their long, tireless progress through the air; we observe them making various movements and evolutions, the reason for which is hidden from us; how then can we say that the aeroplane of to-day is the final solution of the problem?"

Meanwhile, achievement upon achievement were apparently establishing the aeroplane. At the same time, the flying world was full of ideas. Taking advantage of the general enthusiasm, the bogus company-promoter, generally in alliance with some

perfectly sincere but completely mistaken inventor, was obtaining money from the public for the purpose of building some wonderful machine.

We are concerned, however, more with actual progress and events than with the vagaries of inventors, which are only referred to in order that the reader may have a true conception of that momentous epoch. It is important to remember what I have already said with regard to the leading scientific men who were alive to the fact that with but an incomplete knowledge of the air and of natural flight it would have been presumptuous to regard the aeroplane of the time as the final type.

The year 1910 was famous for its great cross-country flights. Some of the most remarkable were made in the great French competition known as the Circuit de l'Est. This was for a flight in stages from Paris towards the German frontier near Nancy, thence to Mezières, to Douai, Amiens, and back to Paris, a distance of close on 500 miles. The winner was Alfred Leblanc, who, like Aubrun, the only other competitor who completed the distance in reasonable time, flew a Blériot monoplane. Leblanc had had long experience in ballooning, a hobby which he followed during the moments of leisure obtained from the management of a large metal-working establishment in France. When the flying machine became practicable he left his business and joined Blériot, and it was he who made all the arrangements in connection with the first cross-Channel flight. He attributed his success in the great circular flight largely to his experience as a balloonist, which familiarised him with recognising localities in the air. Cross-country flights of over a hundred miles were common at this time, and, as we shall see in a later chapter, aviators were employed in military manœuvres with great success. Some of the great flights of the year were Bielovucic's journey from Paris to Bordeaux; Weymann's 250 miles' flight with a passenger from Paris to the summit of the Puy du Dôme; Curtiss's flight across Lake Erie; Wynmalen's, Legagneux's,

and Mahieu's flights from Paris to Brussels; the crossing of the Alps by Chavez; and Tabuteau's flight across the Pyrenees. About the three last a few words more are necessary.

When the organisers of the Milan aviation meeting of September 1910 announced a big series of prizes for a flight across the Alps, they were universally condemned for offering a temptation to competitors to risk life in order to provide spectators with a thrilling episode. The accomplishment of such a feat, it was pointed out, would not carry the new science a step further. This contention was perfectly correct. At the same time, when Georges Chavez accomplished the flight at the sacrifice of his life, it was impossible, in spite of the outburst of indignation and horror, not to see that he had succeeded in going far towards convincing a still partially sceptical world that humanity was destined to disport itself in the air just as it does on that equally alien element the water. The task set in the trans-Alpine competition was to fly from Brigue in Switzerland, over the Simplon Pass, across Lake Maggiore to Varese and Milan, a distance of ninety miles. Properly to appreciate the task it is necessary to remember that even by flying close to the ground competitors would have to fly as high as, at that time, any aeroplane had ever flown. The starting-point was 3280 feet above the sea-level, and the top of the Simplon Pass is 6580 feet high. During the flying the Simplon Pass was closed to traffic, in order that a motor ambulance could swiftly follow the competitors. The route was marked by sheets of linen and by pillars of smoke rising from fires of pitch. The competitors were Aubrun, Cattaneo, Chavez, and Paillette, on Blériot monoplanes; Weymann, on a Farman biplane; and Wienczziers, on an Antoinette monoplane. All the competitors used the Gnome motor. Of these competitors only Chavez dared the feat.

In mountainous country the atmosphere is generally in a disturbed condition, due to the interruption to currents of air, to the swift changes of temperature, and, in the case of the Alps,

to the snow and the ice. From Brigue to Simplon Pass and thence to Lake Maggiore provided the most perilous parts of the journey. In the event of the break-down of the motor, entailing a glide to the ground, it would have been almost a miracle if with the cleverest manœuvring the most skilful pilot succeeded in avoiding dangerous rocks and pine forests. The end of the journey was comparatively easy, being over the lake and a flat plain.

Chavez, who had waited a week for a favourable moment to start, ascended on Friday, September 23, at 1.30 P.M. He was seen at various points *en route*, and a railway train in its passage across and through the Alps was stopped on the Italian side in order that the passengers might see the aviator pass. No one knows what Chavez experienced in that memorable flight. It is certain that he did not follow his intended path, which included a short-cut from Gabi to Domodossola permitted to monoplanes in the competition, but took the longer route prescribed for biplanes. From snatches of conversation permitted to him while lying wounded in hospital, it was gathered that over the Simplon Pass he encountered high winds. The aeroplane swerved from side to side, and several times narrowly escaped being dashed to pieces against great rocks. On arrival at the Domodossola valley, Chavez perceived the signals and made preparations to descend at San Diamanti. He was unable to explain the cause of the accident, which, accordingly, we must give from the accounts of eye-witnesses. On the Italian side of the Alps the aeroplane came into view soon after two o'clock. When over Domodossola it was seen to be descending, and apparently it came straight towards the landing-place, just south of the town. It is believed that the aviator misjudged the distance from the ground, for instead of coming to a nearly horizontal position for landing, his machine struck the ground head foremost at an angle of about thirty degrees, and toppled forward and collapsed. Chavez lay for some days in hospital, and it was hoped that he would recover, but he died on

September 27th. It is said that on recovering consciousness in hospital he exclaimed: "Heaven be thanked! oh, ye Alps, ye are conquered!"

There are two theories of the accident. One is that the aviator was benumbed by the cold and could neither see nor feel clearly. Another is that something in the machine broke. In the latter case it is not improbable that cold may have been the cause.

Chavez was a Parisian, the son of a Peruvian father and a French mother. He was educated in France, and was an all-round sportsman, being a particularly good football player. He held the altitude record for flying to a height of 8040 feet.

Immediately after Chavez started on his Alpine flight, Weymann, the American competitor, ascended; but he came down again after flying for thirteen minutes, and did not really set out upon the journey.

Crossing the Alps has always been an ambition of man. In 218 B.C., Hannibal took his army across the St. Bernard Pass in fifteen days. In 1800 Napoleon took an army across in five days. The first train ran through the Simplon tunnel in 1906, performing the journey in thirty-seven minutes. In 1871 the Mont Cenis tunnel was opened; and in 1881 the St. Gothard tunnel was opened.

It was only a few days after the death of Chavez that Tabuteau flew across the Pyrenees from San Sebastian to Biarritz, where he landed in the Square.

A flight that aroused tremendous enthusiasm was that of the American, Moissant, from Paris to London in August 1910. The fact that he took twenty-one days to complete the journey scarcely detracted from the merit of the feat, for the delay was caused when only fifty miles from London by a long spell of bad weather and a series of little accidents. Moissant flew in one stage from Paris to Amiens, ninety miles, and from Amiens *viâ* Calais to Tilmanstone near Deal, ninety-five miles. The rest of the journey was completed in small stages at long intervals.

On being stranded in Kent he insisted upon remaining there until the weather permitted him to fly, because he had never been to London in his life and was resolved that his first visit should be by flying machine. On this flight he carried a French mechanic as passenger. Moissant was by profession an architect, but he had had an adventurous career in the civil wars of Central America; and he had invented an aeroplane before learning to fly the Blériot machine.

At the end of the year Sopwith won the £4000 prize given by the Baron de Forest for the longest flight on an all-British machine from England to the Continent. The machine he used was a Howard-Wright biplane driven by an E.N.V. motor. A few weeks later King George V. invited Sopwith to fly from Brooklands to Windsor, and on January 31, 1911, the aviator safely accomplished the journey, his Majesty greeting him on his descent and conversing with him on the subject of flying.

The uses to which the aeroplane could be put were now warmly discussed. The army authorities of the leading Powers no longer hesitated to recognise the possibilities of aerial navigation to armies in the field. The building up of aerial fleets commenced, and the training of officers and men in this difficult work began. This, however, will be dealt with more fully in a special chapter. In passing, it is interesting to note that Hubert Latham, Louis Bréguet, and two or three other leading aviators now wore the Cross of the Legion of Honour. Hubert Latham, by the way, in the French army—which, of course, is made up of all the able-bodied male citizens of the republic—was Private Latham of the 1st Engineers; Louis Paulhan was a lieutenant. Officers who flew were officially regarded as being on active service.

International questions as affecting aerial navigation soon cropped up, and the Continental Powers claimed the right to impose customs duties on articles landed from the skies and to take measures against spying. A German military aviator, however, Captain Engelhardt, losing his way in the air, descended

Topical Press

MILITARY MANŒUVRES IN PICARDY

Latham making an aerial reconnaissance.

on French territory, near Nantes. He fully expected to be arrested as a spy, but was allowed to depart in peace.

The French were quick to perceive the possibilities of the flying machine for use in the colonies, and detailed projects for establishing aerial communication in Madagascar and the Sahara began to be discussed. Captain Cortier, of the French Colonial Infantry, who about this time returned from a visit of inspection of the military posts along the desert, brought forward the following considerations. The distance, as the crow flies, between Algiers and Timbuctoo is about 1500 miles. Between these two points are a number of oases which are fairly populous. The aerial route could follow the Saoura, a valley which contains plenty of water. Having passed that, the real desert begins. There are two possible routes. The more feasible is the eastern of the two, which follows a number of deep valleys and is more hilly, but is more thickly populated and better supplied with water. Suitable landing-places would have to be appointed, but for the last 950 miles of the journey there are no inhabited places and no oases. All the relay places over this area, therefore, would have to be established artificially.

This, then, was the beginning of practical consideration of the flying machine. In that year, too, dirigible balloons were used for passenger services in Germany and Switzerland.

Renaux flew from Paris to the summit of the Puy du Dôme on the 7th of March, 1911, a remarkable combined distance and altitude feat. And in the same year took place a series of important international aerial races which severely tested the capacity of machines and men. A flight contest from Paris to Madrid, involving the crossing of the Pyrenees, was one of the first. Its start was marred by a strange and terrible accident. A great crowd had assembled at Issy and the troops failed to keep perfect control, with the result that groups of privileged spectators strayed over the ground. Train, on a monoplane of his own design, had motor trouble, his machine refusing to get well clear of the ground, and, being

almost uncontrollable, plunged into a group of spectators with the propellor still revolving. The group included Monis, the Premier of France, and Berteaux, the War Minister. The latter was killed instantly, and the former was severely injured. Vedrines had already started, and although this terrible event put a cloud over the whole race he won his way through to Madrid, a distance of 727 miles. He and Gibert were both attacked by eagles while flying in the mountainous regions. Vedrines avoided his assailant by a quick descent, and Gibert frightened his eagle away by firing his revolver.

When watching the behaviour of birds in the presence of aeroplanes it is difficult to believe that they are not reflective and critical. One would have supposed that there is no living creature on wings that would not be terrified by the great size of an aeroplane and by the roar of its engine; but even small birds will fly quite near to a flying machine, although very often I have seen the noisy ascent of an aeroplane put flocks of them to confusion. The eagle incident is, however, quite credible. When learning to fly at Salisbury Plain I had over and over again occasion to be amazed at the audacity of peewits. Sometimes I have seen them flying below me and performing their marvellous aerial manœuvres without showing any sign of alarm, but for all the world as if they desired to show a poor human how to do it; and during one of my certificate-flights two peewits took up position a few yards in front of the machine and steadily flew in advance of me.

The Paris-Rome-Turin was the next great race, and it brought out some wonderful performances. Very difficult country had to be flown over in the last stages, there being scarcely any possible landing-places.

A great flight round part of Germany, a race from Paris *viâ* Brussels, Utrecht, London, and back to Paris, and the Round-Britain circuit for a prize of £10,000 were events illustrating man's increasing power of flight.

CHAPTER XXVI

INCIDENTS IN AIRSHIP DEVELOPMENT

THE year 1910 will ever be memorable as that in which cross-country flying became extensively practised, aviation definitely breaking away from the limitations of the flying meeting held in an enclosed aerodrome. Cross-country flying was the feature of the year. The same year saw also the achievement of a number of famous enterprises in the dirigible balloon.

For the first time in history airships crossed over the Channel from France to England and from England to France. True, an airship had previously made an involuntary passage of the sea, for the ill-fated "Patrie," an airship of the Lebaudy type, had three years before, in November 1907, drifted from her moorings, and, fortunately with not a soul on board, blown across the Channel and the Irish Sea, had come to earth in Ireland, and then, before it could be secured, had drifted over the Atlantic. But on October 16, 1910, a non-rigid dirigible which had been ordered on approval by the Parliamentary Defence Committee with a view to making up the aerial deficiencies due to the neglect of the new science by the British authorities made a successful voyage from Compiègne to Wormwood Scrubbs, in London. That the voyage was not made until a favourable wind sprang up does not much detract from the merit of the undertaking; for to make the exact point intended and to harbour without mishap in the huge shed that had been set up through the enterprise of a newspaper showed the British public that there were far greater possibilities in the airship than they had believed.

The airship performed the journey of about 220 miles in six hours, so that its average speed was about thirty-eight miles per hour, of which the favouring wind accounted for seven or eight at least. The navigator was Clément, the constructor, and with him were five assistants and a passenger representing the Parliamentary Defence Committee. The appearance of the airship over London on a Sunday morning created an immense sensation, for although the vessel had been promised for over a year, and was, therefore, expected, the public were not aware that the start had actually been made. Afterwards the British Government agreed to acquire the airship, but on terms which the makers would not accept. The deficiency was, however, made up by private generosity. It was found that the envelope was leaking, and a new one was necessary, a fact which no doubt led the Government to regard the price originally asked as excessive.

This airship had a cubic capacity of 245,000 feet; it was 250 feet in length, with a diameter at the largest girth of 44 feet; it was driven by two motors of 125 h.p., and was estimated capable of carrying a crew of twenty men. The same vessel had been employed with some success in French military manœuvres.

The next airship to cross to England was the Lebaudy, purchased for the nation by the subscription organised by the *Morning Post*. This was of the semi-rigid type, and was built by the same makers as was the "Patrie." The voyage of the Lebaudy was made on October 26th. She carried a crew of eight, and traversed the distance between Moisson and Aldershot in 6 hours 5 minutes. The conditions were scarcely so favourable as when the Clément-Bayard crossed the Channel, there being considerable fog and the wind being abeam, so that the performance was a much better one in every way. An unfortunate accident marked the termination of the voyage. The airship had safely landed and was being hauled into the shed when the top of the gas-envelope caught in the roof and was ripped open. This was in no sense a fault of the vessel, but was due to the fact that the shed placed at its disposal was far too small.

The British representative on board the Lebaudy on this historic voyage was Major Sir Alexander Bannermann, who had just been appointed to the command of the aeronautical division of the army. On May 6, 1911, in a trial trip this airship was almost completely wrecked in a bad landing. It is not necessary to describe the two voyages, which passed without incident. The interest they have for us is that they were the first of the kind, and that they were made by the first large airships acquired by the British army.

The Lebaudy airship had a cubic capacity of 350,000 feet; she was 337 feet long, and was driven by two motors of 135 horse-power. The semi-rigid type to which she belonged differs

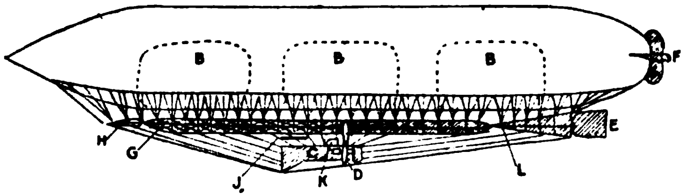


FIG. 24.—THE LEBAUDY SEMI-RIGID AIRSHIP.

B, ballonnets; C, car; D, propeller; E, rudder; F, stabilising planes; G, rigid frame; H, front adjustable plane; J, horizontal plane; K, petrol reservoir; L, rear adjustable plane.

from the non-rigid like the Clément-Bayard, in having a metal frame under the gas-envelope, which is thus preserved in better shape when partially deflated by leakage or other causes. This frame also enables the car to be suspended in a manner that does not distort the gas-envelope.

As an instance of individual enterprise and courage, the voyage of the Willows airship from Cardiff to London and, later in the year, from London to Paris, are far more memorable. In spite of numerous difficulties, due chiefly to the lack of adequate means for so big an undertaking, E. T. Willows when quite a young man began to build his first dirigible balloon. It was of the non-rigid type, and differed little from others of this type.

There were, however, certain originalities in the construction. But the main interest lies in the fact that by great perseverance the young engineer accomplished his purpose, finished the airship and, although he had never made an ascent even in an ordinary balloon, demonstrated its navigability. He had made many short voyages in the neighbourhood of Cardiff, and on one occasion came to earth in front of the City Hall, but in London these little ventures attracted little attention. The enthusiasm was all the greater therefore when the young aeronaut during the night of August 6th made his lonely voyage from Cardiff to the metropolis, landing two or three miles east of the Crystal Palace instead of in the grounds of that place as had been his intention. Owing to the smallness of his gas-envelope—only some 25,000 cubic feet—very little spare petrol for the motor could be carried, so that having overshot his mark he found he could not manœuvre back again. On November 4th he started on a voyage to Paris, and in one stage crossed to Douai, a highly successful feat. From that time bad weather hindered him, and he only completed the journey after delays that lasted for weeks. It was a voyage strongly resembling, in this respect, the aeroplane journey from Paris to London by Moissant. In France a curious experience befell Willows. The French Customs authorities demanded their toll, consenting, however, to waive their claim provided he left French territory before a certain date. Adverse weather prevented him from doing this through the air, and finally he had to dismount the airship and return by more prosaic means.

The Wellman airship started on an attempt to cross the Atlantic from Atlantic City for Europe. The balloon was essentially the same as that in which Wellman made his abortive attempt at an aerial voyage to the North Pole. It was the largest non-rigid dirigible in existence, having a cubic capacity of about 350,000 feet, and its net lifting capacity was about six tons. The principal mechanical contrivance introduced for this attempt was the remarkable equilibrator, or guide-rope.

This was 180 feet in length, and weighed about two tons. It was attached to the car by a steel cable 320 feet in length which ran through the entire length of the equilibrator. About 100 feet of the equilibrator was composed of a series of cylindrical reservoirs fitted to each other by a kind of ball and socket joint, so that they looked like a tremendous chain of which each link was over a yard long. These reservoirs contained spare gasolene, and each could be raised independently into the car so that its contents could be used for consumption in the motors. The remainder of the guide-rope was made up of blocks of wood reinforced by steel bands and jointed to each other in the same manner as the gasolene tanks. The purpose of this equilibrator was the same as that of any other sea-floater or trail-rope, namely, to preserve the altitude of the balloon without the loss of ballast or of gas. The slightest ascensive movement took a portion of the chain off the water, checking the rise by its weight; and whenever the balloon was brought to a lower altitude by reduced temperature or the deposit of rain, part of its burden was borne by the water. Sea-floaters had been tried with success on various occasions, but only in calm weather, and Wellman, as I pointed out at the time he was making his arrangements, depended on a fairly strong breeze to help him across the Atlantic. There was, therefore, considerable danger that the use of the ballast-trailer would lead to trouble by acting as a drag on the airship's progress, causing her to plunge down towards the waves. This is precisely what happened, and the result was that the airship was very nearly wrecked before her crew abandoned her and took to their lifeboat. Wellman admitted in his account of the voyage that the ballast-trailer was a "fatal mistake."

With every possible appliance in the way of signalling apparatus, wireless telegraphic installation, and instruments, the airship started on October 16th with Walter Wellman in command, assisted by Vaniman, his engineer, a wireless operator, an assistant engineer, and a mechanic. For a considerable distance

their course was north-easterly, and they were not far from land. From time to time wireless messages were received telling the world of the progress made, but from noon of the 17th to the afternoon of the 19th there was no news. Then came a wireless message from the steamer *Trent* as follows:—

"At 5 A.M. sighted Wellman airship 'America' in distress. She signalled by Morse code that she required assistance and help. After three hours' manœuvring and fresh winds blowing got Wellman with entire crew and cat. They were hauled safely on board. All are well. 'America' abandoned in latitude 35·43 north, longitude 68·18 west."

So ended an enterprise doomed from the first to failure, but none the less interesting and certainly all the more intrepid.

From the account of the voyagers it appeared that very early the equilibrator proved unmanageable, and there was a constant tendency, even in a light wind, for it to drag the airship down. Further, the vibration transmitted from the waves through it to the car very nearly wrecked the machinery. After a journey of about 300 miles the course of the airship could no longer be directed, and she drifted towards the south. The rescue occupied several hours, and it was only accomplished at great risk. Indeed, the airship's lifeboat was holed by the equilibrator and two of the crew received injuries. The reference to the cat in the telegram is to a black pussy taken on board for luck. Certainly the rescue of the entire crew in so hazardous a case must be counted fortunate, but whether it was due to the cat or not cannot certainly be stated. That the crew troubled to save the animal is evidence of the high esteem in which it was held. The airship had been at sea about seventy-one and a half hours, so that the time-record for an aerial voyage was not quite broken, that being seventy-two and a half hours made in an ordinary balloon by Colonel Schaeck of Switzerland. As to the distance travelled by the Wellman, it cannot be accurately determined, and in any case, being for the most part simply

·THE RESCUE OF WELLMAN

The end of the First Attempt to Cross the Atlantic by Airship.

drifting before the wind, it would not count with the dirigible "records."

The navigator of the vessel, by the way, was Captain Murray Simon, an Englishman, and it was largely to his skill and courage that Wellman generously attributed the saving of the crew. From his narrative, which was published in the *Daily Telegraph*, the English newspaper which, in conjunction with the *New York Times*, fathered the enterprise, a short extract is here given to illustrate the daily life on an airship engaged on a long voyage:—

"I am free to confess that the supreme novelty of our adventure, the exquisite and undefinable sense of well-being and happiness one experienced in mid-air, when it was calm and the equilibrator was not jerking us into various stages of nervous prostration, helped to buoy us up.

"Even in moments of crisis there was no lack of discipline, no murmuring against orders. We were as one happy aerial family, each striving his best to reach Europe by the air route, and each conscious almost from the first time we understood the action of the equilibrator that we had only the faintest chance of being successful, but still there was that chance, and being sportsmen we pressed towards our goal.

"Apart from the equilibrator the airship generally was a success. The gas was well retained, the machinery was good, and the steel car stood the tremendous strain successfully.

"Our greatest difficulty, I think, was how to get sleep. The 'America' airship was not designed as a luxurious dormitory, but if the beds and pillows had been of the softest down, and if we had had cabins as comfortable as Atlantic liners, we could never have rested well.

"That alarming switchback railway called the Rocky Road to Dublin, which is a series of ups and downs and rapid convulsive jerks, was nothing compared to the unexampled series of whacks and bangs and pangs of our unfortunate equilibrator; and so it happened that when we almost collapsed with fatigue we simply slept for a few minutes at a time, and always we dreamed.

"As regards myself, my dreams were generally unpleasant, and

I find that the crew also had a very similar experience. It was lucky that we met the *Trent*, but in our lifeboat, with a good navigator, skilled in seamanship, a good crew, and furnished with plenty of provisions, we could have held our own for two or three weeks.

"As to the feeding aboard the airship, we did pretty well. We did not have regular meals, but ate indiscriminately—just a bite of biscuit now and then and a sup of water, as we felt disposed; but on one occasion young Aubert made the most delicious dish of bacon and eggs I ever tasted.

"The weather was rough most of the time, but never real storms in the sailor's sense; but just winds and fairly heavy seas. Just how rough it was and how calm we always knew by the movement of the equilibrator.

"Whilst Jack Irwin was talking to Atlantic City he was annoyed by another fellow trying to cut in. He heard the Atlantic City man calling to the other fellow, 'Shut up, you—you blithering idiot; an airship's on the line!'

"8 P.M.—Beginning to feel fagged at the wheel, which I have had since starting. Saw a schooner dead ahead in the fog. Put the helm hard to starboard, and just cleared her, our bilge passing over her spanker, and must have given the gang aboard the deuce of a fright. We up in the air, with the motor spouting fire, and going like blazes over them, the equilibrator clanking down below. I would like to get my shipmates' thoughts of us.

"9 P.M.—Wind hauling to eastward, dangerous; thought we would be driven ashore on Long Island, but luckily we managed to weather the land.

"The cat seemed still unhappy, and would not eat. Vaniman wished we had not brought her, but I said unless we kept her we should never have a bit of luck. Kitty refused all kinds of canned goods.

"*Sunday*, October 16, 4 A.M.—After twenty hours at the wheel was relieved by Wellman. Lay down to sleep by the wheel, not caring for hammock, and left orders to be called if anything was sighted or any trouble. Stopped big motor just before I fell asleep, turning sidewise to wind and drifting. Not sure of position; too foggy to get horizon.

"8 A.M., *Sunday*.—Saw a fisherman. Discovered by accident what Kitty would eat. While Irwin was eating biscuits and canned

goods and passing Kitty the meat he dropped a piece of biscuit. She pounced upon it and devoured it. Broke up four biscuits, and Kitty ate them all.

"10.30 A.M., *Sunday.*—Heard Atlantic City asking Siasconsett for news about airship. Heard Siasconsett answering all was well aboard. Tried to reach both stations, but failed.

"12 Noon, *Sunday.*—Ship straining fearfully. Thought she would go to pieces at any moment. The steel frame must be wonderfully built to resist the equilibrator's pounding."

CHAPTER XXVII

THE DEATH-ROLL OF THE AIR

"WE must avenge our dead," said Louis Blériot when the death of Léon Delagrange, his fellow-worker and friend, was announced to him. That is the spirit in which the heavy casualties of aviation's early years was received. Even in the closing months of 1910, when the rate of mortality was fearfully heavy, there was no hesitation on the part of those who were engaged in aeronautical work in marching forward; there was no diminution in the number of pupils. Outside aeronautical circles were to be found a few people who said that men were obviously never to conquer the air, that flying machines could not be made even reasonably safe, and that it were better to abandon the idea. These counsels, however, carried no weight with those who were studying aeronautical science.

Great interest always attaches to the earliest martyrdoms in any cause. And it must ever be remembered that those who were first sacrificed in the pursuit of flight were facing fearful odds. They took risks which they knew, and they knew full well that there were unknown dangers besides. The lessons of the deaths of Lilienthal and Pilcher killed on motorless aeroplanes could not be ignored, and with the first successful flights by the Wrights in America and by Santos-Dumont, Farman, Ferber, Delagrange, Voisin, and Blériot in Europe, there were soon plenty of bad tumbles to remind experimenters of their peril. This made not the slightest difference, nor did the line waver when the list of the dead began to look like the death-roll of a battle.

To achieve flight at all, aeroplane and motor had to be

extremely light. And for some years designers were the slaves to a fetish of lightness, even after improvements in the motor rendered it unnecessary. The result was that many lives were sacrificed through the collapse of machines in the air. But the uneven nature of the struggle is shown further in the fact that the science was in its infancy: men knew certain facts about the air, but there was a vast unexplored field for experiment and research. In effect, men were building flying machines in the dark.

The death-roll was increased by the mistakes of aviators and by their folly in attempting feats of a sensational nature to please the crowd. But it was quite well known that the greater number of aeroplanes were, in certain conditions to which they might be exposed in any flight, likely to bring down pilot and passengers to death or serious injury. The science was so incomplete that no one knew the amount of strain to which an aeroplane might be subjected during flight. It was impossible to estimate the weight of blows delivered by gusts on various parts of the machine. All this time there was an incessant striving after great speed, and the erroneous idea was put forward that high speed alone ensured stability. Nothing could be further from the truth; meanwhile, aviators were being sacrificed.

Makers of machines too often ignored the fact that a perfect condition of the atmosphere rarely, if ever, exists. Even the lightest wind is made up of a succession of gusts. It is necessary to go into this matter here in order to realise the nature of the unequal struggle on which aviators were engaged. Once it has risen off the ground a flying machine is practically indifferent to wind. It moves about at its own independent speed in any direction in the air, which may or may not be moving. The independent speed and direction of the aeroplane are modified by the speed and direction of the air. Colonel Renard once said, "To the aeronaut wind does not exist; it is the earth that moves."

But every aerial vessel has a certain amount of inertia; in other words, it does not instantly respond to a change in the

direction or the velocity of the wind: there is a moment during which it resists, and it is at this moment that it is subject to abnormal strain. Going with the wind the aviator experiences a curious sensation in every brief acceleration of its velocity; that is, in every gust of a following wind. Owing to the inertia of his machine such a gust causes a momentary loss of speed relatively to the air, and the aeroplane falls suddenly downwards in what Léon Delagrange used to call "a hole in the air." Each gust is followed by a comparative lull, and this has the opposite effect, causing the machine to take an upward plunge. In the case of an opposing wind the effect of a gust and a lull are just the opposite, and when flying with a wind abeam the strain caused by gusts affects the machine transversely. These bare facts were known, but they were not sufficiently taken into account and studied. Further, no one knew with what power a gust would suddenly bear upon a machine. The variations in the strength of winds had never been properly analysed, and no one could say whether a machine was liable to be hit with what was, in effect, a ten-ton steam-hammer or whether the blow might not have a force of twenty tons. No one could say definitely what was the limit of strain to which any individual member of an aeroplane would be put.

Having these facts in mind, the folly and the danger of putting forward the theory that high speed alone insured safety will be seen. If a machine did not break under the strain of a gust it would have a powerful tendency to move out of equilibrium, to dip, or to rise, or to cant to the right or the left; and a high-speed machine would require much more skill to restore to a safe course than a slow one.

As a matter of fact, the question of the stability of the machine had practically been settled in the earliest days of aviation. There were numerous devices by which men knew how to overcome the tendency of a machine to tilt up on either side or in the line of flight. True, some of these devices were clumsy; but others were good, and with a more accurate

knowledge of the atmosphere and with the acquisition of greater skill and experience the problem of stability was solved. Far graver was the problem of rendering a machine structurally sound enough to sustain the strain of being forced back into equilibrium against the power of a gust. To imagine that high speed would overcome all difficulties of this kind was the most absurd error that could have been committed.

Makers and aviators, it is true, recognised the need for making machines strong and durable, but their chief concern appeared to be to make the leading edge of the planes very strong and to pay little attention to the tremendous strains put upon the wings sideways and upon the tail, rudder, and elevator. As we shall see, other considerations were ignored, with fatal results.

It was soon found from analysis that accidents due to the giving way of some part of the machine in the air could be arranged in classes. It was found that biplanes usually broke at the tail or the connections therewith, and that monoplanes usually broke at the main wings.

In view of the unknown dangers with which aviators were confronted, it is surprising that the death-roll was not far heavier than it was. Up to the end of 1910 there was one fatal accident to about 3500 miles flown. Curiously, the mortality of ballooning was, on the basis of mileage, heavier than that of aviation. But in spite of the fact that aviators in some cases threw their lives away in attempting sensational feats, the death-rate was slowly diminishing. After all, men have never taken any step forward without the loss of life. In the early days of cycling there were numerous accidents, and riders of the wheel were regarded as acrobats. Going farther back we find that even mail coaches were considered very dangerous. A London newspaper in 1790 printed the following:—

"The plans of mail coaches are becoming universal; America, France, and Ireland have them already under consideration. It is to be hoped, however, they will build their carriages upon a more mechanic principle than the English do at present. High

hung bodies, gibbet-boxes, low front wheels, all the weight forwards, and the guard on the box are all repugnant to the principles of expedition. The frequent overturns of these coaches is owing to frequent greasing the wheels and neglecting to secure the linch-pins. Had they oil-boxes they might run 500 miles without greasing."

This interesting paragraph was quoted by the *Westminster Gazette.*

With regard to the early martyrs of aviation, it was impossible to fail to observe that almost without exception they met their death at the aviation meeting or in making demonstrations before an applauding public. Of the thirty-three fatalities up to the end of 1910, only two occurred in cross-country flying.

The first aviator killed on a motor-driven aeroplane was Lieutenant T. Selfridge. This accident occurred on September 11, 1908, at the very time that Wilbur Wright was proving to an astonished world by his demonstrations in France that flying was possible. His brother was carrying Lieutenant Selfridge as a passenger at Fort Meyer, near Washington. While in full flight one of the propellers struck a connecting-wire between the rudder and the main planes and was smashed. The rudder was rendered useless, the driving power from the other propeller being on one side of the machine. In the fall Selfridge was killed and Orville Wright was severely injured.

It was almost a year later before another martyr was claimed. On September 7, 1909, E. Lefébvre, who at the first aviation meeting at Rheims had evoked the admiration of the British Chancellor of the Exchequer on account of the great skill he displayed, ascended at Juvisy in a new Wright biplane, which may or may not have been properly examined. At any rate it turned over, the reason, it is surmised, being that the control either gave way or refused to work; and Lefébvre was killed. He was a self-taught aviator, and was an engineer. Fifteen days later Captain F. Ferber, a scientific aviator and experimenter whose contributions to aeronautical science were of great im-

portance, while descending from a flight in a Voisin biplane at Wimereux, near Boulogne, turned suddenly in an endeavour to avoid a brook, and the machine capsized. The aviator's fall was quite trifling, but, unfortunately, the heavy motor landed on his back, causing injuries which proved fatal a few hours later. Before dying Ferber said, "I was foolish. I was flying too low. It was my own fault. It will be a severe lesson to me. I wanted to turn round, and was only five yards from the ground." An account of Captain Ferber's work will be found in a previous chapter. His loss was a very severe blow to the cause of aviation. In the same year Antonio Fernandez, on December 6th, was killed at Nice owing to the collapse in the air of his biplane, a machine of his own design. The accident was due to the breaking of a control-wire which had been loosely mended with cord. An examination of the machine showed that the cord had been broken before and the ends had been knotted—incredible carelessness, affording a lesson which was not taken to heart sufficiently by other aviators. Fernandez was a Spaniard who had a tailoring establishment at Paris and another at Nice. He built his machine with the help of his assistants. He had tried this machine at the first meeting at Blackpool, but without success. The machine had some of the points of the Wright, the Voisin, and the Curtiss biplanes.

The year 1910, which saw the deaths of twenty-nine aviators, five dirigible balloonists, and sixteen travellers in spherical balloons, opened in its first week with a lamentable tragedy in the loss of Léon Delagrange at Bordeaux on January 4th. Delagrange, who had first been associated with Voisin in biplane flying, had a few months before transferred his allegiance to Blériot and the monoplane. He flew at the Doncaster meeting first on a Blériot monoplane of the cross-Channel type driven by an Anzani engine, and then on the same machine driven by a Gnome 50 h.p. motor, with which combination he achieved the then record speed of 49·9 miles per hour. The use of this engine without greatly strengthening the machine was criticised, but

Delagrange continued to use it. At Bordeaux, while flying over the sheds in the aerodrome, the left wing of his monoplane broke in the centre and afterwards snapped at the point where it is attached to the body. The machine immediately fell, and the aviator was killed.

Léon Delagrange was the son of an Orleans business man, and early in life studied art and became a sculptor of great promise. He brought to aeronautics a singularly fine temperament, in which the idealist was blended with the practical man. He was universally beloved, and his death caused consternation in England as well as in France.

This accident gave rise to the interesting controversy referred to on page 167 concerning the supposed gyroscopic effect of a Gnome motor. The theory found many supporters, as also did the theory that the speed of the machine driven by this motor was too much for its structural strength. Aviators experienced in the use of the Gnome engine, both with monoplanes and biplanes, find that it has no appreciable gyroscopic effect. The problems involved are somewhat intricate, and this is scarcely the place to go into a discussion which adequately treated would require many thousands of words. In later Blériot machines the structure was strengthened, but this apparently *did* not altogether prevent accidents.

On April 2, 1910, Hubert Le Blon was killed at San Sebastian owing, it is believed, to the collapse of his Blériot monoplane in the air. This is the generally accepted theory, although it is interesting to record the fact that at the official inquiry into the accident the doctors who examined the body of the dead aviator stated that it was conceivable that he may have had a seizure caused by acute indigestion, brought on possibly by the strain and excitement of flying immediately after a meal, and that this may have paralysed his action. His body was not in the least injured by the fall into the water near the shore, and it is believed that had assistance been on the spot and it had been possible to pull him out of the

water, under which he was held by his machine, his life would have been saved.

Le Blon was endeared to the British public as much as was Delagrange, for he was that hero who at Doncaster, as narrated in an earlier chapter, avoided falling into a crowd of people by wonderful presence of mind. He was a motor-driver, and had driven in several races.

The next martyr was Hauvette Michelin, who was killed at Lyons on May 13th. Flying an Antoinette monoplane, he collided with one of the mark-towers on the course. The accident would not have been fatal had it not been for the extraordinary mischance that while lying on the ground the broken flagstaff fell upon him, its end striking him at the back of the head. On June 18th, Thaddeus Robl was killed at Stettin while flying an Aviatic biplane in a high wind. This accident was caused by the clamouring of a crowd of thoughtless spectators who demanded a flight in spite of the unsafe conditions. The next fatality was on an Antoinette monoplane which collapsed in the air on July 4th at Rheims, its driver, Charles Wachter, falling from a height of about 500 feet. This was unquestionably due to the structural weakness of the machine.

Great Britain offered up the next sacrifice in the person of Charles Stewart Rolls, our foremost aviator. On the morning of July 12th, the second day of the Bournemouth aviation meeting, an alighting competition was being held, the task set being to land in a marked ring and to come to a stop as nearly as possible to the centre of the ring. Two or three attempts had been made, the competitors coming up with the wind and on that account making rather poor shots at the mark. This ring was within a few yards of the rails, which were separated by a distance of about thirty paces from the grand stand, a long structure of a height of about 40 feet. The wind was blowing across the aerodrome towards this stand. Rolls perceived the advantage of descending in the face of the wind, and he therefore soared

upwards in his Wright biplane far over the grand stand, and then circled round to make his attempt. He reappeared to the view of those in the grounds over the top of the shed, and when at a height of about 100 feet he shut off his engine and began to glide downwards on what appeared destined to be a most successful flight. He had cleared the stand and had got almost directly over the rails when at a height of about 60 feet the tail of his machine gave way. The noise of the rending of wood could be distinctly heard, and the left side of the tail could be seen breaking away. This was apparently at the instant that the pilot was endeavouring by a quick movement of his control to bring the machine up to a horizontal keel from the angle of about 45 degrees at which it was tilted in its descent. The next moment the elevating planes in front broke down, and the whole fore-and-aft control of the machine was disorganised. The machine dipped downwards on its nose and turned over, striking the ground almost exactly in an upside down position, with what was left of its front elevators facing towards the grand stand. The crash was tremendous, and it was accompanied by a loud report, probably caused by the rending asunder of one of the cylinders of the engine, part of which was buried in the ground to the depth of some inches. Poor Rolls was killed instantly, but by the mischance of striking the ground with his head, the cause of death being concussion and shock. It was the worst possible loss that British aviation could have sustained.

The cause undoubtedly was the weakness of the tail. The machine was a Wright biplane made in France. The tail-piece was an innovation designed by the French Wright Company, and attached to the machine two days before the accident at Bournemouth. Some difficulty was experienced in ascertaining the right method and place of attachment. It was a movable tail working in unison with the forward elevator. Rolls had tried the fixed tail designed by Wilbur and Orville Wright themselves on his cross-Channel flight, and he told me that while this tail had the effect of rendering easier the maintenance of longitudinal

stability he found its effect rather too pronounced, so that at times the machine seemed reluctant to obey the forward elevator.

Daniel Kinet, flying a Farman biplane at Ghent, fell, from some unexplained cause, and died of his injuries on the 15th of July. For a time he was the holder of the passenger-carrying record. Nicholas Kinet, who was no relation to Daniel Kinet, flying at Brussels on a Farman machine on August 3rd, met with a fatal accident, some part of the machine breaking in mid-air.

It is now necessary to review the list of fatalities briefly, except when there is special reason for entering into detail. Lieutenant Pasqua Vivaldi was killed on a Maurice Farman machine at Rome on August 20th. Clemant Van Maasdyk, flying a Sommer machine at Arnheim, on August 28th, was killed through a fall caused by turning too quickly while close to the ground, his machine consequently striking the earth on one side. The alleged gyroscopic effect of the Gnome motor was by some held to account for this accident. At Chartres, on September 25th, Poillot, flying a Savary biplane, was killed; and two days later Georges Chavez succumbed to injuries received in his fall in the rough descent he made at the termination of his brilliant flight over the Alps. He was undoubtedly suffering from exposure, and he may have misjudged the landing and handled the machine clumsily. On October 1st, Heinrich Haas was killed at Metz through the breakage of a chain on his Wright biplane. Plochmann was killed at Habsheim on September 28th while flying an Aviatic machine (the German-made Farman). The next accident was also on a Farman, an aviator named Matsievitch being killed at St. Petersburg on October 7th from some unexplained cause.

An extraordinary story was told concerning the fatal accident to Captain Matsievitch. It was said that the aviator was a Nihilist, and that the heads of the movement decided upon him to be the assassin of a high military officer who had made himself particularly objectionable to the revolutionary party. Captain Matsievitch was told to take the officer up in his

machine and then deliberately bring about an accident, so that both pilot and passenger should be killed. The decision of the secret society being implacable, Matsievitch had nothing for it but to agree, and it only became a matter of finding an opportunity. This came in the ordinary course of events. Matsievitch was a brilliant flyer, and at an exhibition at St. Petersburg several notabilities were taken up as passengers by the aviator. It came to the turn of the man who was to be offered up to the vengeance of the Nihilists; but just as the ascent was about to be made, detectives approached the aviator and bound him on his oath as a soldier to do nothing calculated to risk his passenger's life unduly. Whether they suspected the possibility of a plot, or were merely exercising an ordinary precaution in view of the exalted rank of the passenger, is not stated. At any rate, Matsievitch regarded his oath as sacred, and brought the passenger down safely. Immediately, the head of the society ordered that their disobedient member was to commit suicide within twenty-four hours, failing which he was, in a manner to be decided, to be killed. On the following day Matsievitch went up in his machine to a great height, and suddenly, without any apparent reason, was seen to lose control of the aeroplane, which fell to earth and was completely wrecked, the aviator being picked up dead.

A French military officer, Captain Madiot, flying a Bréguet biplane at Douai on October 21st, had a fatal fall through an error of driving; and on October 25th a German officer, Lieutenant Mente, was killed at Magdeburg through making a descent at a steep angle with his motor working, and so subjecting his machine to a strain which was too much for it. On October 26th Blanchard, flying a Blériot monoplane at Issy, was killed, his machine for some unknown reason overturning in the air. On October 2nd Saglietti, an Italian officer, was killed, his machine breaking during the execution of a gliding descent. The next victim was an American, a daring and skilful aviator named Ralph Johnstone, famous for his high altitude flights.

To please a sensation-loving crowd he was attempting circus feats in the air. On November 17th, in the execution of one of these, his machine broke under the terrific strain. Then a double fatality took place: two Italian military aviators, Cammarato and Castellani, flying a Farman at Centocelli, were both killed through the machine breaking in the air on December 3rd.

Cecil Grace, an Englishman, while flying from Calais in an attempt to reach the English coast, was lost at sea on December 22nd. He was flying a Short biplane. The wind had a westerly direction, the strength of which the aviator probably underestimated. A mist rendered navigation difficult. The machine was seen near the North Foreland on a northerly course, and the aviator was never seen again alive.

Grace was steering his machine by compass, but no compass can be of any use to an aviator while he is out of sight of land, or is, for any reason, unable to ascertain the exact direction of his flight. The head of the machine may be kept to a certain point, but the line so given may be very different from that of the machine's actual path. Over land the aviator can take observations with the aid of a good compass, and will be able to ascertain the exact deviation from his course caused by the wind; but unless he can take these observations his compass is of very little use. Even during a brief disappearance from the land the strength and direction of the wind may change, and the aviator may be quite oblivious of the fact, and, while keeping his course by compass, may be driven far from his proper line.

It is not improbable that the wind may have freshened after Grace started, and at the altitude at which he was flying. At any rate, there is little doubt that while he kept the head of his machine to the north-west the actual path he took was about N.N.E. He was seen passing the Foreland, but it must be remembered that although he was seen from land he may not himself have been able to see the coast. It is sometimes extremely difficult to see land two miles away and 1000 feet down. It seems only too likely that soon after Grace passed the Fore-

land he realised, from the hour, that he had gone astray, and he may have turned back, as he supposed, towards the French coast. With only sea and sky in sight there was nothing to indicate to him the amount of leeway he was making. It is conceivable that even if the wind had veered half round the circle he would have been quite ignorant of the fact. Turning round he headed his machine towards the south-east; but the wind all the time was carrying him steadily away in an easterly direction.

What is needed is an instrument which will tell the aviator of a change in the wind independently of observations of the earth. Probably we shall never have such an instrument. In long voyages over the sea the aviator will have to take astronomical bearings.

Another double fatality is now to be recorded, Laffont and Paula being killed on December 29th on an Antoinette. On December 30th, Lieutenant de Caumont was killed at Buc on a Nieuport monoplane. On the last day of the year there were two American fatalities—John B. Moissant, flying a Blériot at New Orleans and taking a rather absurd risk, met with a fatal accident; the other was that of Hoxsey, who was attempting a very dangerous manœuvre at Los Angeles. He was flying a Wright biplane, and was endeavouring to show that he could descend at a tremendously steep angle and then recover the machine quickly.

And in the following year there were many further fatalities to deplore. But an analysis showed that the number of deaths decreased when considered in proportion to the amount of mileage flown. Thus in the first four months of the year there were ten deaths, which in point of time was in the same proportion as in the previous year; but in these four months it was estimated that twice as much flying took place as in any previous four months.

The moral of many of these accidents is too obvious to dwell upon. In 1910 five persons were killed in a dirigible balloon accident, the Erbslöh, already referred to. Two parachutists and sixteen passengers in ordinary balloons were killed.

CHAPTER XXVIII

WAR IN THE AIR

NO sooner had a means of ascending into the air been discovered by the two Montgolfiers than its importance to the art of war was perceived. The first public exhibition of ballooning was in the year 1783. Europe was about to be turned by French revolutions and by the boundless ambition of Napoleon into an armed camp. It might be said that war at that period was the principal industry of the civilised world. It is not surprising, therefore, that in the year that saw the first demonstration of ballooning, Girond de Villette made an ascent and pointed out the advantages which must result from its use in war. Five years later the Committee of Public Safety considered ballooning as an aid to the defence of the country. And at this time Meusnier and Guyton de Morebeau were at work on the problem of the dirigible balloon. At the siege of Conde in 1794, attempts, which however proved futile, were made to communicate with the besieged by means of unmanned balloons.

In those days, as now, the urgent needs of the military spurred the inventiveness which would ultimately be for the benefit as much as for the destruction of men. Urged on by de Morebeau, the chemist La Voisier, who had discovered a new method of making hydrogen, set to work to turn it to practical account. "With the help of a physicist named Coutelle," writes Hildebrandt in his *Airships Past and Present*, "they proceeded to construct an oven which was to be used for preparing hydrogen by passing steam over red-hot iron. This was soon ready, and the balloon, 30 feet in diameter, was

filled with the gas in the gardens of the Tuileries. The experiment succeeded so well that Coutelle was sent on a mission to General Jourdan, who was commanding the armies on the Sambre and Maas, with a view to induce him to make use of a captive balloon. It so happened that when he arrived in Belgium he was received by a member of the National Assembly. To him the idea of a military balloon appeared so ridiculous that he threatened to shoot Coutelle. General Jourdan, on the other hand, was much struck by the plan, and instructed Coutelle to return to Paris and procure the necessary materials."

But before we relate how aerial vessels were employed in battle for the first time, let us try to picture the impression made upon humanity by this wonderful new element in the affairs of the world. Carlyle, in his *French Revolution*, refers to this episode in a passage of singular interest:—

"What will not mortals attempt? From remote Annonay in the Vivarais, the brothers Montgolfier send up their paper-dome filled with the smoke of burnt wool. The Vivarais Provincial Assembly is to be prorogued this same day: Vivarais Assembly members applaud, and the shouts of congregated men. Will victorious Analysis scale the very Heavens then?

"Paris hears with eager wonder; Paris shall ere long see. From Reveillon's paper warehouse there, in the Rue Saint Antoine (a noted warehouse), the new Montgolfier airship launches itself. Ducks and poultry have been borne skyward: but now shall men be borne. Nay, Chemist Charles thinks of hydrogen and glazed silk. Chemist Charles will himself ascend, from the Tuileries Garden; Montgolfier solemnly cutting the cord. By Heaven, this Charles does also mount, he and another! Ten times ten thousand hearts go palpitating; all tongues are mute with wonder and fear; till a shout, like the voice of seas, rolls after him, on his wild way. He soars, he dwindles upwards; has become a mere gleaming circlet—like some Turgotine snuff-box, what we call 'Turgotine-Platitude'; like some new daylight Moon! Finally he descends; welcomed by the universe.

Duchess Polignac, with a party, is in the Bois de Boulogne, waiting; though it is drizzly winter, the 1st of December 1783. The whole chivalry of France, Duke de Chartres foremost, gallops to receive him.

"Beautiful invention; mounting heavenward, so beautifully—so unguidably! Emblem of much, and of our Age of Hope itself; which shall mount, specifically light, majestically in this same manner; and hover—tumbling whither Fate will. Well, if it do not, Pilâtre-like, explode; and *de*mount all the more tragically! So, riding on wind-bags, will men scale the Empyrean."

The first military balloon factory was established towards the end of 1793 at Meudon. In the making of the envelopes for the balloons, by the way, was employed a varnish the secret of whose composition has been lost, just as has the secret of some of the unfading blues used by the Old Masters been forgotten. Whether this varnish was superior to all those at present in use is unknown, but it had a very high reputation. In the early military balloon messages were sent down on paper by means of a small sand-bag along one of the ropes. Much the same method is now used for drawings and photographs. Speaking-tubes and flag-signals were also used.

The first military balloon division was formed on the 2nd of April 1794. The division included a drummer-boy! The uniform of this branch of the service consisted of a blue coat with black collar and facings and red braid. The buttons bore the word "Aerostiers." These soldier aeronauts were armed with swords and pistols. Within two months of their formation they were employed in the battle against the Austrians at Maubeuge in the first and one of the most dashing exploits in military ballooning.

The incident is a curious one. These soldier aeronauts, it appears, because they were artisans, were regarded with contempt by the swashbuckling, fire-eating warriors that in those days made battles, with the result that their commander,

Coutelle, begged for an opportunity to distinguish themselves. This was given to them. An ascent was made under fire, and, one way and another, a sub-lieutenant was killed and two of the men were badly wounded. But the work done was invaluable. Never had been such accurate reports of an enemy's movements. The Austrians objected strongly, and not only objected, but had a superstitious dread of the aerial monster. General Jourdan, himself, made several ascents. In the same month ascents were made near Charleroi, and also at the battle of Fleurus, describing which Carlyle wrote: "Or see, over Fleurus in the Netherlands, where General Jourdan, having now swept the soil of Liberty, and advanced thus far, is just about to fight, and sweep or be swept, hangs there not in the Heaven's Vault, some Prodigy, seen by Austrian eyes and spy-glasses: in the similitude of an enormous Wind-bag, with netting and enormous Saucer depending from it? A Jove's Balance, O ye Austrian spy-glasses? One saucer-scale of a Jove's Balance; *your* poor Austrian scale having kicked itself quite aloft, out of sight? By Heaven, answer the spy-glasses, it is a Montgolfier, a Balloon, and they are making signals! Austrian cannon-battery barks at this Montgolfier; harmless as dog at the Moon: the Montgolfier makes its signals; detects what Austrian ambuscade there may be, and descends at its ease. What will not these devils incarnate contrive?"

The battle was won, and the victory was attributed largely to the work of the balloonists. The Austrians announced that all balloonists who fell into their hands would be treated as spies.

From time to time balloons were used in wars in Europe, and in 1798 the First Company were ordered to Egypt. On the way thither the vessel containing them was sunk by a British man-of-war. A second company was captured. Then, in 1799, Napoleon disbanded the balloon division. Some of their material was sold and some was sent to Metz for storage. The story goes that Napoleon disliked the balloon after the

Bolak

DEFENCE AGAINST AERIAL ATTACKS

A German high-angle gun on its motor carriage. This gun can be "trained" for nearly vertical fire. The marksman takes aim by means of mirror sights.

day on which one sent up in his honour descended on the tomb of Nero.

But the French army had not had their last experience of balloons, apart from the revival in military aeronautics which took place about the year 1840. On entering Moscow in 1812, Napoleon's legions found in the camp of Voronzoff a large balloon bearing many thousands of pounds of gunpowder which was to have been launched upon them. It was fitted with wings, and it was intended to hover over the French army and destroy Napoleon and his staff. The French made attempts to raise it, but without success.

In their bombardment of Venice in 1849 the Austrian army, at the suggestion of Uchatius, an artillery officer, employed balloon torpedoes. It was found that the range of the besieging batteries was insufficient, so Uchatius devised paper balloons, each capable of carrying bombs weighing 30 lbs. for thirty-three minutes. These were sent up from the windward side of the town with a time-fuse contrivance. By this means bombs were dropped in the streets, and although little material damage was done the moral effect was great.

The next big occasion for the use of military balloons was provided by the American civil war, General MacClellan making excellent use of them with the co-operation of Professor Lowe. As an instance of what can sometimes be done by a balloon, it may be mentioned that a man named Le Mountain passed right over the enemy's camp, took very complete observations, and then, ascending higher, found a current of air which took him straight back to his friends. Ascents and descents under heavy artillery fire were made on several occasions, and on May 24, 1862, General Stoneman from his position in a balloon directed the fire of the artillery with great effect. Important work by balloons was done at Chikahoming, and later at Fair Oaks and Richmond, where a balloon was attached to a locomotive and moved from place to place. On August 16, 1862, the position in the James River of the fleet under Wilkes was exposed by a balloonist.

The siege of Paris brought the balloon into service under most romantic conditions. No fewer than sixty-six balloons left the besieged city, some to fall into the enemy's hands, others to convey important personages from isolated Paris, others to convey letters, and two to be lost at sea. In the same war the Germans formed two balloon detachments under the direction of the English aeronaut Coxwell, but very little service to the invading force was done.

The balloon service in besieged Paris was under the control of the brothers Eugene and Julius Godard and Yon and Dartois. The Godards had charge of the Orleans railway station depot, the other firm had the northern station. Godard's balloons were coloured red and yellow or blue and yellow, the balloons of Yon and Dartois were white. During the siege 66 aeronauts, 102 passengers, over 400 carrier pigeons, 6 dogs, and 9 tons of letters and telegrams were carried out of Paris through the air. Of the carrier pigeons, 57 returned to the city with messages. Five of the dogs were sent back, but nothing more was heard of them. Five balloons were captured by the enemy.

Some remarkable things were done with the aid of these balloons. On one occasion Tissandier threw down 10,000 copies of a proclamation addressed to the German soldiers. It demanded peace, but asserted that nevertheless France was prepared to fight to the end. On October 7th, Gambetta left Paris in the balloon "Armand Barbes" with the object of organising a fresh army in the country districts to march to the relief of the beleaguered city. The balloon came perilously near the earth close to the German outposts, and shots were fired, one striking Gambetta in the hand. By throwing ballast the balloonists escaped before worse could befall them.

The first duel in the air occurred in connection with the siege of Paris. The French balloon "Intrepide" was seen floating near the fort at Charenton and a second balloon was in the air at the same time. On account of the vagaries of the air-currents these balloons were slowly approaching each other.

Both flew the French colours. When very close together rapid shots were heard below, and one aeronaut was seen to fling himself into the network of his balloon and to cling to its side. The "Intrepide" descended rapidly, and suddenly the French flag of the second balloon was removed and a Prussian flag flaunted in its place. It is related that the French balloonist on reaching ground repaired a hole in his balloon and ascended again, continuing the fight with such effect that the Prussian balloon fell, and its occupant, now wounded, was rescued with great difficulty by a troop of Uhlans. Not much credence is given to this story, which, however, was believed in Paris at the time.

The Pigeon Post was conducted in such an interesting manner that it is well worth describing. It was organised by the Paris Pigeon Fanciers' Society. After one successful experiment a regular service was instituted. The despatches, of course, had to be very small and light, and recourse was had to microscope photography. By this means sixteen pages of print containing 32,000 words could be reduced to a small packet measuring 2 inches by 1¼ and weighing less than a grain. These messages were sent from all over France into Paris. One pigeon could carry twenty of them. On arrival at the pigeon-cote in Paris the messages were taken from the bird, and the sheets, enlarged, were thrown on to a screen and thence copied. The charge was a halfpenny per word. The Prussians endeavoured to harrass this post by sending up hawks, but without very good results.

Great Britain has used balloons in war as much as any country. In the Egyptian campaign of 1882 and in the South African trouble in 1885 balloons were employed with good results. In the Boer War of 1900 they were employed by General Buller on the Tugela and during the battles of Vaalkrantz, Spion Kop, and Springfontein. On the 10th of February a balloon was shot down by the Boer artillery. When Roberts and Kitchener rounded up Cronje, the position of the

Boer army was located by means of balloons and the artillery fire was directed by signals.

Italy employed balloons in its Abyssinian campaigns and the Dutch used them in Atschin.

Kite balloons were used by both sides in the Russo-Japanese war; and in manœuvres in France, Germany, and England dirigible balloons and aeroplanes are now regularly employed, and with steadily increasing effect.

The first aeroplane used in actual war was employed by the United States in February 1911 to observe the Mexican frontier near Juarez during some revolutionary fighting in Mexico. The aviator was Charles Hamilton, and the machine a Wright biplane. Aeroplanes were also used by the military authorities in France during the "Champagne Riots" in 1911.

Curtiss demonstrated the possibility of alighting upon and ascending from a cruiser's deck, which had, however, to be adapted to the purpose by means of a large temporary platform; and he also adapted an aeroplane to ascend from and alight upon water.

"The aeroplane has proved that it is a marvellous instrument of war," wrote Clémentel in presenting the French War Minister's budget for 1911. Aeroplanes were extensively used in the manœuvres in Picardy in the autumn of 1910. Taking at random the report of one aerial reconnaissance, one finds that after a voyage of sixty-five minutes, during which the scout followed an appointed route of sixty kilometres, he was able to disclose four important positions occupied by the enemy. The aeroplane was kept at an altitude of about 1500 feet, and during part of the journey it followed the flight of one of the enemy's aeroplanes. The altitude, although not out of range, was a fairly safe one for an aeroplane moving at about forty miles per hour.

CHAPTER XXIX

THE ROMANCE OF THE FUTURE

DAZZLING is the prospect opened by the conquest of the air, but, like everything else, it is necessary to look ahead and to picture the accomplishment of the things that are not yet possible in order to appreciate it. When wireless telegraphy was first shown to be possible, many were the fascinating speculations as to its effect on our daily life. These speculations have been realised, but nobody now concerns himself with the romantic side of wireless telegraphy. It is almost commonplace. So with aerial navigation. It is gradually being taken for granted. While men wonder, the thing is done. But looking ahead has its fascination and its usefulness. What are the limits of aerial navigation? Is it politic to assume that there is any limit to human progress? Will flying ever be within the reach of the man of average means? In what services will aerial craft be employed? Horace Walpole in a letter written in 1783 wrote:—

"T'other night I diverted myself with a sort of meditation on future airgonation, supposing that it will not only be perfected but will depose navigation. But I chiefly amused myself with ideas of the change that would be made in the world by the substitution of balloons to ships. I supposed our seaports to become deserted villages, and Salisbury Plain, Newmarket Heath, and all downs (but *the* Downs) arising into dockyards for aerial vessels."

The idea of aerial navigation has aroused the imaginativeness of many writers, great and small. H. G. Wells, in his

story, *When the Sleeper Wakes*, gives a view of the world as he imagines it 300 years hence. He describes two kinds of machines: one is a big aeroplane carrying hundreds of passengers; the other is a small aerial "top" carrying but one or two persons and buzzing about like a fly. In an interview which appeared in the *Evening Standard* on the eve of 1911 he said:—

"I am rather impressed with the fact that the type of flying machine we have now is not that which is likely to prevail ultimately. The machines now are merely instruments for extraordinary feats of gymnastics in the air, and can only be controlled by quite exceptional men. It is not to the sphere of aviation as practised at present that I look for the flying machine of the future. That is much more likely to be developed in experimental laboratories than under the stimulus of prizes and gate-money, and I am convinced that when it appears it will be on entirely different lines from existing aeroplanes. The most promising work that I know of at present is that of Captain Dunne, who has been pegging away for a number of years at the problem of automatic stability. The time will come when flying will be the ordinary means of rapid locomotion all the world over for long distances. That is a very distant prospect—perhaps a matter of a century. I prophesy an enormous amount of progress in mechanical contrivances in the next few decades, but it seems to me that what is probable is altogether trivial in comparison with what might be done. Supposing a country had the courage to spend money in quite enormous sums relatively to the present endowment upon research and systematic inquiry, and upon education to keep pace with the inquiry, we should, of course, very speedily make a social system altogether different from anything we had hitherto known, and altogether finer, securer, and happier. Some day or other some country will make this extraordinary plunge forward, and then all the things that trouble us at the present time will disappear automatically, and, in short, most of the miseries and troubles of life as we know them at the

Aerial Scouts in Naval Manœuvres

present time will disappear just as darkness and confusion disappear when you turn on the light."

Kipling shows us the transatlantic aerial mail of the future:—

"The rudder that assured us the dominion of the unstable air and left its inventor penniless and half blind. It is calculated to Castelli's 'gull-wing' curve. Raise a few feet of that all but invisible plate three-eighths of an inch and she will yaw five miles to port or starboard ere she is under control again. Give her full helm and she returns on her track like a whip-lash. Cant the whole forward—a touch on the wheel will suffice—and she sweeps at your good direction up and down. Open the complete circle and she presents to the air a mushroom-head that will bring her up all standing within a half-mile."

Nobody but Kipling could have written that. It should be an inspiration to the inventor. This airship is gas-lifted, and the gas is kept well in hand by use of the "Fleury Ray," which reduces it to liquid and again to fully efficient gas at will. A wonderful story, if only for the aeronautical terms employed, many of which may well come into use in our time. Kipling, by the way, making one of his characters look back at our own feeble efforts at flight, talks with scorn of "the days when men flew wooden kites over oil-engines."

The regulation of traffic of this kind would be no small matter. Kipling gives us a picture of an aerial world illuminated from below by coloured beams that pierce through thick strata of clouds. As an example I quote the following:—

"Bristol and Cardiff double lights (those statelily inclined beams over Severn mouth) are dead ahead of us; for we keep the southern winter route. Coventry Central, the pivot of the English system, stabs upwards once in ten seconds its spear of diamond light to the north, and a point or two off our starboard bow. The Leek, the great cloud-breaker of St. David's Head, swings its unmistakable green beams twenty-five degrees

each way. There must be half a mile of fluff over it in this weather, but it does not effect the Leek. 'Our planet's over-lighted, if anything,' says Captain Purnall, at the wheel."

So much for the far future; but what will happen in our lifetime. It has been my task at the beginning of each of the last three or four years to endeavour to form an estimate of the progress likely to be made in a twelvemonth. In the endeavour not to allow enthusiasm to carry me beyond reasonable possibilities, I have managed on each occasion rather to underestimate them: the fulfilment has been better than my prophecy. It will be well still to restrain the fervour of anticipation and to err rather on the side of moderation than extravagance. But, guiding my remarks by this rule notwithstanding, the prospect immediately before us is extraordinary. When the new premises of the Royal Automobile Club, opened in 1911, were designed, it was suggested by one of the committee that the architect should be instructed to design the roof flat in order that the contingencies of aerial navigation might be provided against. The suggestion was not accepted, but I should not be at all surprised if within five years of the building of that club aeroplane descents on the roofs of buildings may not be possible. Taking into account the scientific and mechanical developments that are actually within view, it is quite clear that aerial craft will be employed in many useful services in the next few years.

Aeroplanes will be specialised for different purposes, such as racing, carrying, and long-distance flights. Machines will be made that will maintain continuous flight for anything up to twenty-four hours, carrying passengers comfortably, equipped with all the appliances and instruments necessary for long voyages. In them pilot and engineer will be able during flight to vacate their positions and take rest while relief officers control the machine. The motor will be so reliable that only on rare occasions will it fail, and even in the case of a compulsory glide to earth the machines will be so constructed that they

will land quite safely on rough ground and come to a stop without a long run. Machines will be able to descend safely on the surface of the water and to ascend therefrom; but these may be special machines; it does not follow that every machine will be capable of every kind of operation. We shall have small, cheap machines carrying one man.

And with the development of the machine the skill of airmen also will develop. Men will acquire peculiar familiarity with flying. A parallel is to be found by those who recollect it in the development of the bicycle. In the early days of cycling many feats of mounting, riding, and alighting which are now almost instinctive to every rider of the wheel were regarded as belonging to the domain of acrobatics. And not only will the winds and other conditions of the atmosphere be known in a degree that is now almost inconceivable, but conditions that locally set up small variations that are now a peril to the aviator will be understood, quickly grasped, and guarded against by every qualified air-pilot.

A wide range of speeds will be possible; and there will be fast machines and slow machines. We shall have machines capable of 100 miles per hour, although the difficulties that now stand in the way of the safe attainment of such a speed are admittedly very great. It is probable that high-speed machines will have their sustaining surfaces of variable extent, so that in order to descend safely the pilot can enlarge the surface and, at the same time, diminishing the power of the engine, reduce speed and descend comfortably.

The use of public commons and parks will, of course, be denied to flying machines, but there will be a great extension of the practice of aeronautical societies acquiring grounds for flight. With the extension of flying these societies will spring up everywhere, and their flying grounds will be maintained by subscriptions and by money received at the gates. There will be flights from one ground to another, inter-club competitions, and there may even be league competitions. The step will be

a short one to regular aerial routes and passenger-carrying services. Already a beginning is in sight. Flights between established flying grounds are becoming regular. Aviators are becoming familiar with certain routes and with the aerial conditions encountered in them. They are becoming acquainted with the good landing-places on these routes. It will not be long before landing-places are marked on special maps and are indicated by some sign on the ground. Local authorities, indeed, will provide landing-places and keep them in order, and stores of petrol will be kept near them.

Flying by night, which has already been accomplished, will be rendered easy by the provision of well-lighted stations at frequent intervals. Numerous codes for indicating the locality to aerial navigators have been suggested, and the signs employed will at night be lit up so that they can be seen from a great height. Efficient codes in conjunction with special maps will render the task of finding the way fairly easy.

The special maps for aeronauts will show those features which are easily recognised, such as white roads, railway lines, water, and woodland. Contour maps are of no use, for seen from above undulations and hills are not recognisable. But the aeronaut's map must have the heights above sea-level plainly indicated. On the ground, too, there must be movable signs in charge of responsible officials, who will by their means be able to inform travellers in the air as to the exact direction of the wind, with possibly some indication of its velocity.

It is impossible to foretell to what extent the dirigible balloon will develop. At present it is so much at the mercy of the wind that it is of comparatively small value. In favourable weather, however, it can even now be used for reconnoitring and for carrying passengers. It is probably safe to assume that its efficiency will be increased; and then, with the aid of harbours to shelter it when landing in windy weather, and assuming that economies in its manufacture will be effected, it may become of very great value. The provision of shelters will make a vast

Photo by] [*Collier & Son*

THE AIRSHIP IN WAR

The Camp Ground of General Carter's Division near Fort Sam Houston (photographed from an areoplane during the Mexican trouble in the Spring of 1911).

difference, which is readily appreciated when we realise how limited marine navigation would be if it were not for the numerous harbours.

With these probabilities in the evolution of aerial craft it would be easy to point out important changes that the conquest of the air will make in the affairs of men. That it will play a part in the advancement of civilisation is certain. Aeroplane services, including the carriage of mails, in desolate regions, in Canada, Africa, and Australia will soon be established. In sparsely populated lands small aeroplanes by rendering communication easier will play a great part in humanising the lives of the people and keeping them in touch with each other and with the centres of civilisation. Geographical exploration—and there is still much of it to be done—will benefit. Astronomy, too, would be served by any means by which observers could be taken to a great height.

Although it does not appear likely that aeroplanes can descend to or start from points in great cities, there is, after all, no reason why they should not be enabled to do so. When the need arises we shall have lofty platforms erected far above the chimneys and the wires. Flying machines may then be able to descend at a steeper angle than is now possible, but if this be not feasible the platforms will be furnished with some contrivance by which aerial craft can be received, their impetus checked, and brought to a safe stop.

It has been variously prophesied that the conquest of the air will make war very much more terrible, and, on the other hand, that it will stop all war. It is difficult to see why it should have either of these effects; but that it will change the science of strategy and the practice of tactics entirely is quite certain. Used in scouting and reconnoitring it will give commanders more accurate information about their opponents. But their opponents will, to counteract this, devise elaborate ruses. It will not prevent armies from fighting. What is far more likely is that any war between great Powers will begin in the

air, each side endeavouring to discover the lines and centres of mobilisation of the enemy. The rival aerial forces will, during their work, encounter each other and fight. In cases when one side obtains a great advantage in the air, the advantage will lie with that side, for before the enemy has time to re-equip his aerial fleets decisive strategical victories will have been won. Accurate observations of positions tend to reduce the unnecessary sacrifice of life and property. They enable commanders to concentrate their destructive forces on a given objective without having to cut and fire a way through by numerous small actions and by tremendous waste of men and ammunition. It has been said that the cavalry scout is rapidly becoming obsolete. At present it only appears as if his services will not be called for until the aerial part of the war has been fought out, leaving one side, or both, crippled. But a new branch of artillery is being called into being. They will be armed with guns capable of firing at a high angle to a great altitude and delivering projectiles of a specialised nature. Warships also will be armed with guns of this kind. Apart from their use in reconnaissance, aeroplanes and dirigible balloons will unquestionably be employed for offensive purposes. At present it is not seen how they can drop explosives in sufficient quantity to do great damage, but their powers in this direction will rapidly increase. Further, they will often be employed to carry small parties of men rapidly through the air, to land them at points where they can blow up railway lines and cut off other communications, and be off again without the necessity of fighting an action. Clearly the conquest of the air means the evolution of a type of soldier far more highly educated and finely organised than the world has yet seen. Not one whit less courageous than the dashing cavalryman of the wars of fifty years ago, but scientific, cool, calculating, and self-sacrificing.

Aerial forces will form part of the defence of harbours and coasts, and it is probable that a means will be found for rendering them suitable for use in conjunction with fleets of battleships.

Already they have ascended from and descended upon the decks of ships. From that point it is only a question of progressive steps.

He would be a rash prophet who asserted that we have already attained the limit of speed for terrestrial travel. Trains that go at seventy miles per hour, ships that steam at forty knots, may seem unsurpassable, but it is as well to remember that in every age man has said, "This is the fastest!" I would not like to venture to say that aerial travel will always prove swifter than land travel. With regard to the latter, there are possibilities in the mono-rail and in electric power which may give us a common speed of 100 miles per hour. It is difficult to imagine many occasions when so high a speed is really needful for the ordinary affairs of mankind. But, on the whole, it seems likely that air-travel will have the advantage in the matter of speed and directness. By no great effort of the imagination, then, we can see mails, passengers, and emergency goods being carried through the air. People used to say that motor-cars could only be used by millionaires, and would never be employed for the carriage of goods. Now we see them carrying economically the heaviest kind of goods.

Every step of man's progress has been hailed as the signal for the breaking down of the barriers between nations. Probably ages will be required to effect that desirable—if it really be desirable—result. The conquest of the air will have little or no effect in this direction. National boundaries will exist as before. Aerial craft will carry the flags of their country. Foreign intruders will be examined and kept out if necessary. But as the ocean of the air has no natural boundaries, but embraces all countries, its navigators will require the right to travel where they will. This will be theirs upon the condition that they do no damage and cause no discomfort to people below. But there may be other restrictions. Atmospheric roads may be established across countries for the use of foreign aeronauts. These would be broad strips possibly marked on the ground by

conspicuous signals. They would be international. And there would be areas of restriction, to fly over which without permission and without first descending to a landing station and answering all inquiries would be to court pursuit and capture.

A new industry is opened up. There is a tremendous field for the inventor in connection with developments of aerial navigation. It has given a new dimension to thought and has extended and enriched language. The psychological effect will be important. Every form of art will respond. Since the origin of man no forward step of half the importance of the conquest of the air has been made. When prehistoric men first ventured on a rough-hewn log on the then mysterious element, the water, they were untutored savages who had no realisation of the significance of their venture. They had no conception of the modern steamship. Perhaps we, in comparison with those who will people the earth a thousand years hence, are as simple. But at any rate we have some idea of the significance and the promise of our small beginnings in aerial navigation.

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